A CAHNERS PUBLICATION
INTERNATIONAL EDITION
APRIL 3, 1986

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EDN

SPECIAL ISSUE:
Communications Technology

MAP devices find their way into industrial systems

RF and digital ICs cut cost of SSB designs

Hardware accelerators

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERIN

Protocol ICs brea communications barriers

your test programs.

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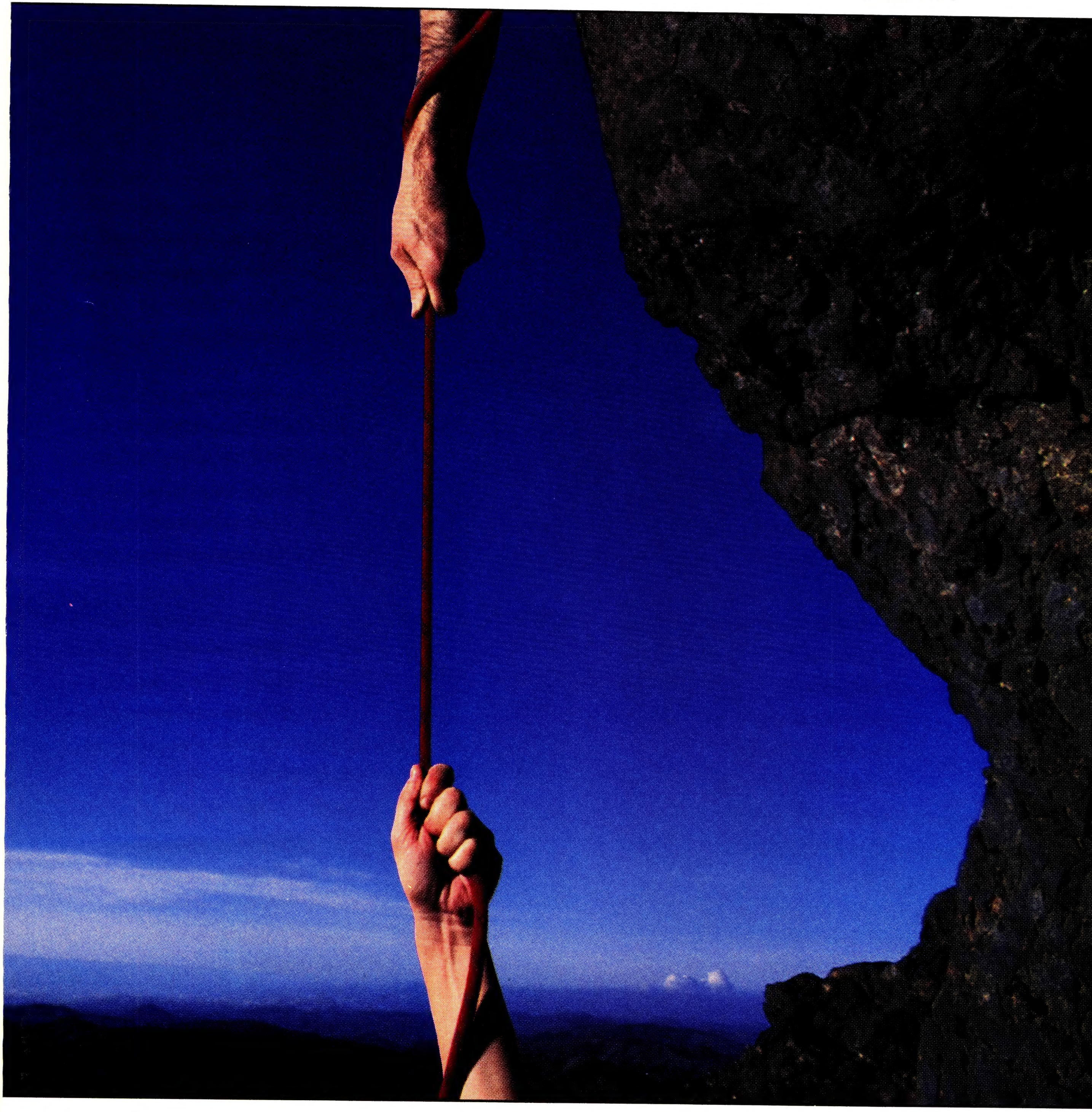
CIRCLE NO 5



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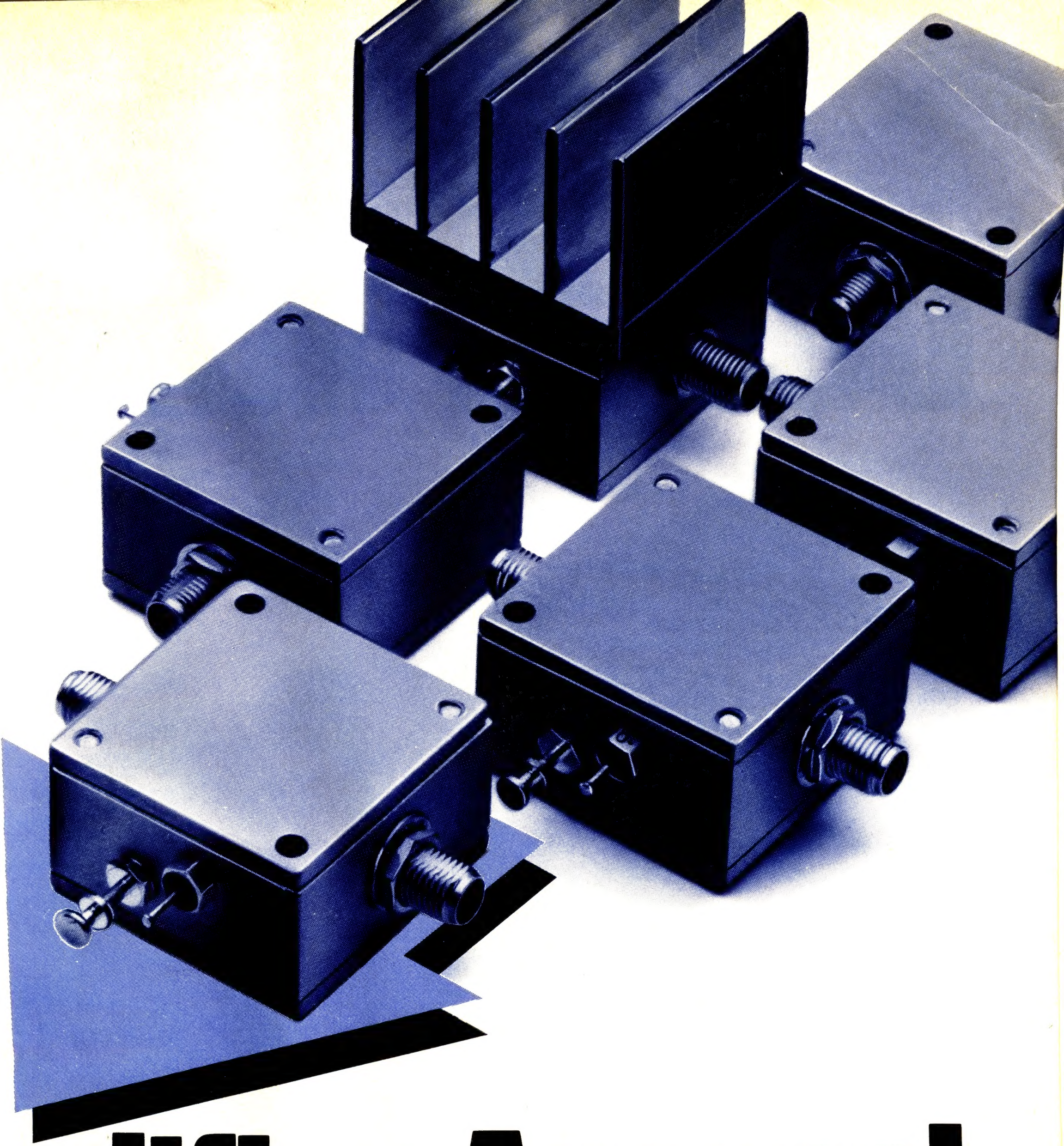
Sometimes you need more than just a hotline.



Amplifier Arsenal

50KHz to 2000MHz, 100mW output Gain Controlled From **$69.95**

Our ZFL-2000 miniature wideband amplifier hit a bulls-eye when we introduced it last year. Now we've added more models to offer you a competitive edge in the continuing battle for systems improvement.

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One week delivery . . . one year guarantee.

Gain the competitive edge . . . specify Mini-Circuits RF/IF signal-processing components.

SPECIFICATIONS

Model No.	**ZFL-500**	**ZFL-1000G**	**ZFL-2000**	**ZFL-1000H**
Freq (MHz)	0.05-500	10-1000	10-2000	10-1000
Gain (dB), Min.	20	17	20	28
Gain Flatness (dB) Max.	±1.0	±1.5	±1.5	±1.0
Max. Power (dBm) (1dB compression)	+10	+3	+17*	+20
NF (dB) typ.	5.3	12.0	7.0	5.0
3rd order Intercept pt (dBm)	+18	+13	+25	+33
Current at 15V dc	80mA	90mA	100mA	150mA
Price $	69.95	199	179	219
qty.	1-24	1-9	1-9	1-9

For complete specs on these and our 1- and 2-W models refer to 1985-86 Gold Book or Microwaves directory.

***+15 dBm below 1000MHz**

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setting higher standards

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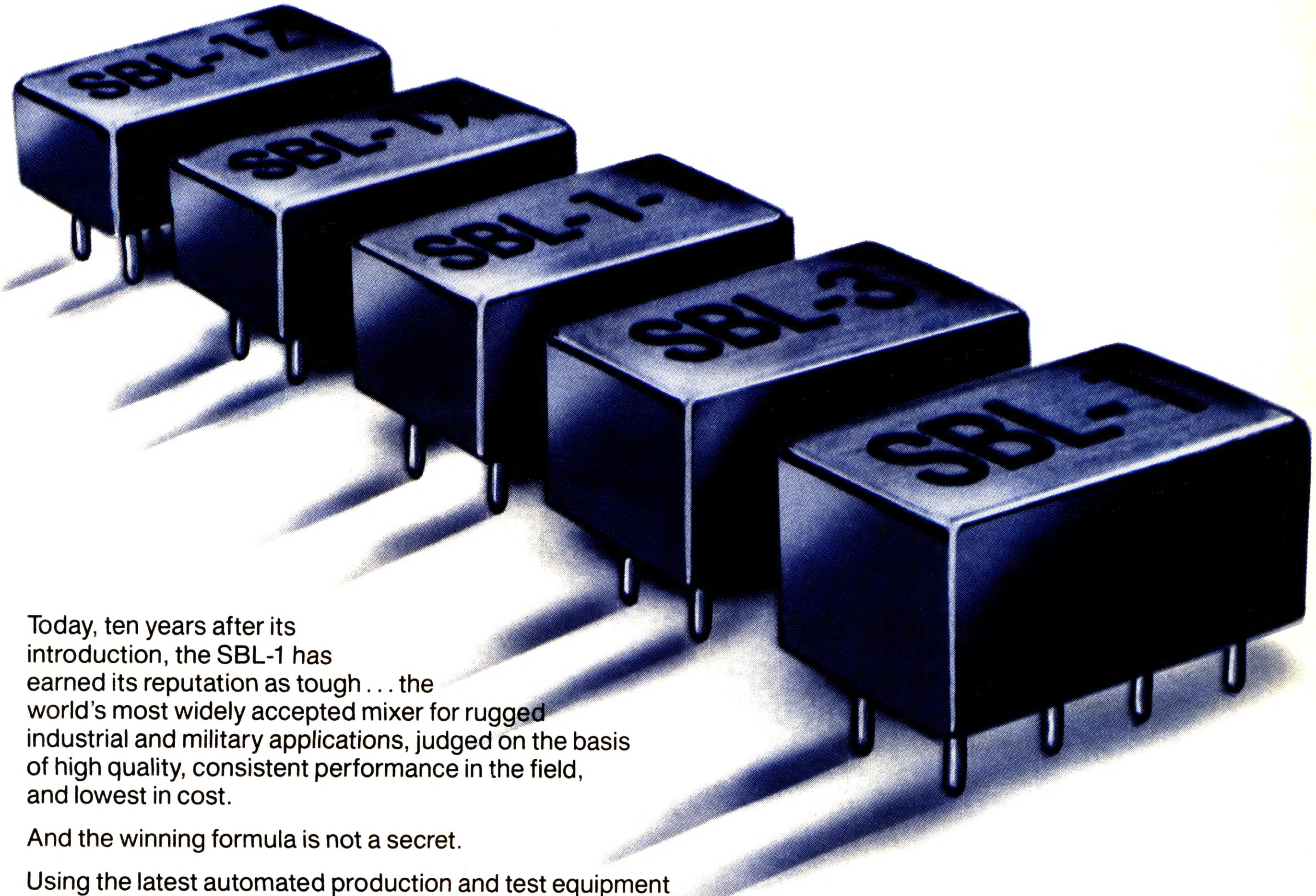
CIRCLE NO 6

C101 REV. A

more tough mixers



Today, ten years after its introduction, the SBL-1 has earned its reputation as tough . . . the world's most widely accepted mixer for rugged industrial and military applications, judged on the basis of high quality, consistent performance in the field, and lowest in cost.

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For full specifications call or write for latest RF/IF Signal Processing Handbook or refer to EEM, Gold Book, or Microwaves Directory.

SBL SPECIFICATIONS (typ.)

Model	Freq. (MHz)	Conv. Loss	Isolation,dB L-R	Isolation,dB L-I	Price (10-49)
SBL-1	1-500	5.5	45	40	**$4.50**
* SBL-1X	10-1000	6.0	40	40	**$5.95**
SBL-1Z	10-1000	6.5	35	25	**$6.95**
SBL-1-1	0.1-400	5.5	35	40	**$6.50**
SBL-3	0.25-200	5.5	45	40	**$7.50**

* If not DC coupled.

finding new ways . . .
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C104 REV. ORIG.

CIRCLE NO 7

Volume 31, Number 7

EDN

April 3, 1986

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

On the cover: *Manufacturers of communications ICs are offering a plethora of protocol chips, ranging from standard UARTs to multiprotocol devices that handle synchronous as well as asynchronous communications. See pg 102. (Photo courtesy Intel)*

COMMUNICATIONS TECHNOLOGY SPECIAL ISSUE

DESIGN FEATURES

Special Report: Datacomm protocol ICs 102

Multiprotocol ICs can support communications for synchronous, full-duplex packet-switching networks. They also support the still-popular asynchronous character-switching networks.

ICs simplify design of single-sideband receivers 119

Single-sideband transmission has served well for decades in radio and telephone systems. Unfortunately, cost considerations have limited its use. Today, state-of-the-art ICs allow you to design low-cost SSB receivers that perform as well as their expensive predecessors.

Universal switched-capacitor filter lowers part count 139

Switched-capacitor filter ICs take advantage of carefully controlled semiconductor processes to deliver tight tolerances without hand tuning; they're suitable for a variety of voice- and data-communications applications.

Bus links peripherals, multiple master in low-speed network 153

The I^{2}C serial bus lets you link microcontrollers to local peripherals or other local controllers, forming a flexible and easily expandable low-speed network.

Designer's Guide to: Linear control-system theory—Part 1 173

Dynamic signal analyzers, which analyze signals in both the time and frequency domains, aid you in taking control-system measurements and in performing other steps in system development, such as analysis, modeling, and design. Part 1 of this 3-part article presents an overview of classical linear control theory.

Continued on page 7

EDN (ISSN 0012-7515) is published 45 times a year, biweekly with one additional issue in January, February, March, August, and December, two additional issues in April, June, July, September, and November, and three additional issues in May and October by The Cahners Magazine Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158. William M Platt, President; Terrence M McDermott, Executive Vice President. Copyright 1986 by Reed Publishing USA, a division of Reed Holdings, Inc; Norman L Cahners, Honorary Chairman; Saul Goldweitz, Chairman; Ronald G Segel, President; Robert L Krakoff, Executive Vice President. Circulation records maintained at Cahners Publishing Co, 270 St Paul St, Denver, CO 80206. Second class postage paid at Denver, CO 80202 and additional mailing offices. Postmaster: Send address changes to EDN, 270 St Paul St, Denver, CO 80206.

IEEE-488

There's only one signal generator that's a better value than the 6060A.

The new 6060B.

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New wider frequency range.

The 6060B has an even wider output frequency range. Low end coverage is extended to 10KHz for VLF and LF applications and still maintains the capability to output frequencies up to 1050MHz.

Better residual FM and amplitude accuracy.

Guaranteed amplitude accuracy is now ±1.0dB from +13dBm to −127dBm, improved from ±1.5dB. You can rely on precise amplitude control across the frequency range.

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Fluke 6060B

Frequency range	10KHz–1050MHz
Amplitude range	+13dBm to −127dBm
Accuracy	±1.0dB
Harmonics	<−30dBc
Spurious	<−60dBc
Modulation	AM/FM
IEEE-488 Interface, opt. 488 switch speed	<100 ms, typ.

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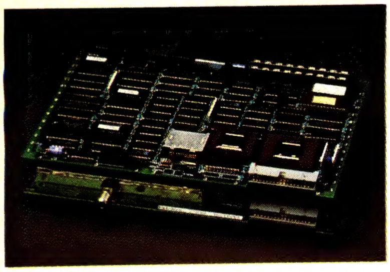
April 3, 1986

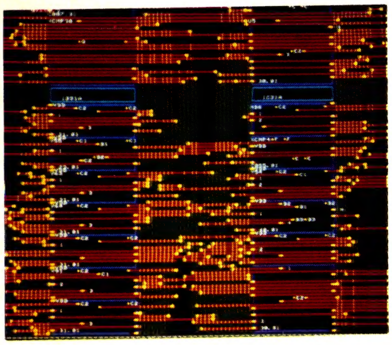
TECHNOLOGY UPDATE



Sensing a large potential market for equipment *that complies with the manufacturing-automation-protocol standard, several vendors have recently introduced box-, board-, and chip-level products that make it easy for you to design MAP compatibility into your systems (pg 51).*

Increasing popularity of MAP spurs market for compatible chips, boards, and boxes 51

The drive towards computer-integrated manufacturing and factory automation is forcing industrial LAN technology to standardize in the direction of the manufacturing automation protocol (MAP). Factory planners are attracted to the MAP's promise of plant-wide sharing of information among all sectors of an organization.



Hardware accelerators *can speed the execution of CAE and CAD programs by a factor of 1000. But the accelerators are expensive and inflexible, so make sure you carefully evaluate competing models before choosing one (pg 63).*

Specialized CAE/CAD hardware accelerators decrease run times for every design step 63

You can now select a hardware accelerator to speed any stage of your computer-aided engineering and design projects. For CAE applications, companies have introduced accelerators that simulate electrical circuits. For CAD applications, you can choose accelerators that lay out pc boards or custom ICs.

PRODUCT UPDATE

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TEK SCOPE MAKES WORLD'S TOUGHEST SERVICE CALL.

On Mt. Everest you don't settle for second best. A scope has to be ready and able to measure under the toughest conditions on earth. For members of the Ultima Thule expedition, that meant a scope from Tektronix.

The team was on Mt. Everest to study the origins and effects of altitude sickness from research stations located at 17,000 and 21,300 feet. To accompany them they chose the Tek 2337 for its exceptional ruggedness and outstanding ease of use. Plus a well-earned reputation for no-compromise performance, no matter what.

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Says spokesman Tom Clement, "Our research efforts were salvaged, at the highest and most critical altitude, thanks to the Tek scope."

For peak performance anywhere, depend on Tek's world-class family of portable scopes. Twelve scopes in all offering either analog or digital storage performance at bandwidths from 60 MHz to 300 MHz. Plus designed-in reliability that helps reduce your measurement costs.

To precisely match your needs, choose from three Tek 2000 family lines. The standard-setting, high-performance 2400 Series. The ultra-rugged 2300 Series. And the popularly-priced 2200 Series. All backed by Tek's 3-year warranty that includes the CRT.

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Many people who use cellular phones, cordless phones, and other 2-way radio communications don't realize their conversations are not private. Several legislators think government should protect certain transmissions from interception. But unenforceable laws are not the answer: The communications industry should use available technology to solve the security problem.

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Falling prices spur sales of copier/printer systems . . . Comm ICs to lead the way in development of GaAs.

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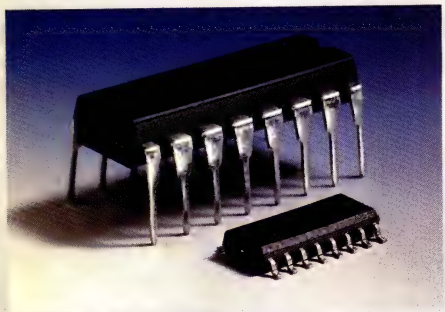
PHILIPS

Electronic
components
and materials

The all-important high-speed CMOS question. Will latch-up cause burn-out?

With Philips high-speed CMOS (HCMOS) logic ICs, the answer's no. Because they're free from latch-up.

What causes latch-up?
Latch-up occurs when SCRs (formed by parasitic bipolar transistors found in all CMOS structures) are triggered by current transients arising from over-voltage at the input, output or supply pins, or by ringing on the signal pins. The resulting short-circuit across the supply rails causes excessive current and inevitably destructive power dissipation.



DIL or SO? The whole range of Philips 74HC/HCT/HCU logic is available in both packages.

How is it overcome?
We prevent any current injection into the SCR structures by growing an epitaxial layer on a very low-resistivity substrate. And by using unique design and process parameters to minimize the gain of the parasitic transistors, we achieved complete latch-up immunity. No burn-out.

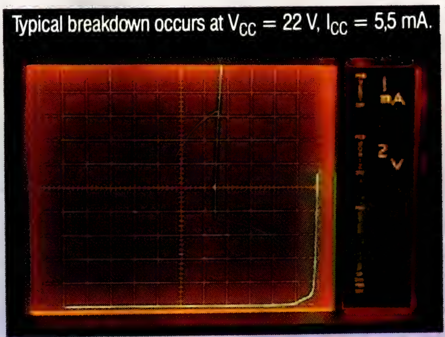
So you improve system performance, and by eliminating additional components to protect against latch-up you not only cut component costs but also optimise system speed.

And you gain reliability. With a product that will not fail during system test. Or in the field.

Harsh environments?
Even in noisy, high-temperature environments such as automotive and industrial applications, Philips HCMOS logic goes on working. And you get exceptional noise immunity because the input switching levels of 74HC/HCU circuits are 30% and 70% of the supply voltage. Moreover, the whole Philips 74HC/HCT/HCU family has a standard temperature range from −40 to +125 °C.

Want to know more? Then call your local Philips organisation (see below). We're on-hand with full technical support and documentation. Including a Designer's Guide with all the answers to your all-important questions about HCMOS.

Typical breakdown occurs at V_{CC} = 22 V, I_{CC} = 5,5 mA.



Curve tracer display from latch-up test with excess supply voltage. At no time did latch-up occur in the Philips HCMOS IC, since the supply voltage snaps back to 13 V.

HCMOS HIGH-SPEED LOGIC **The name is Philips The product is HCMOS**

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RCA is an alternate source for Philips HCMOS ICs.

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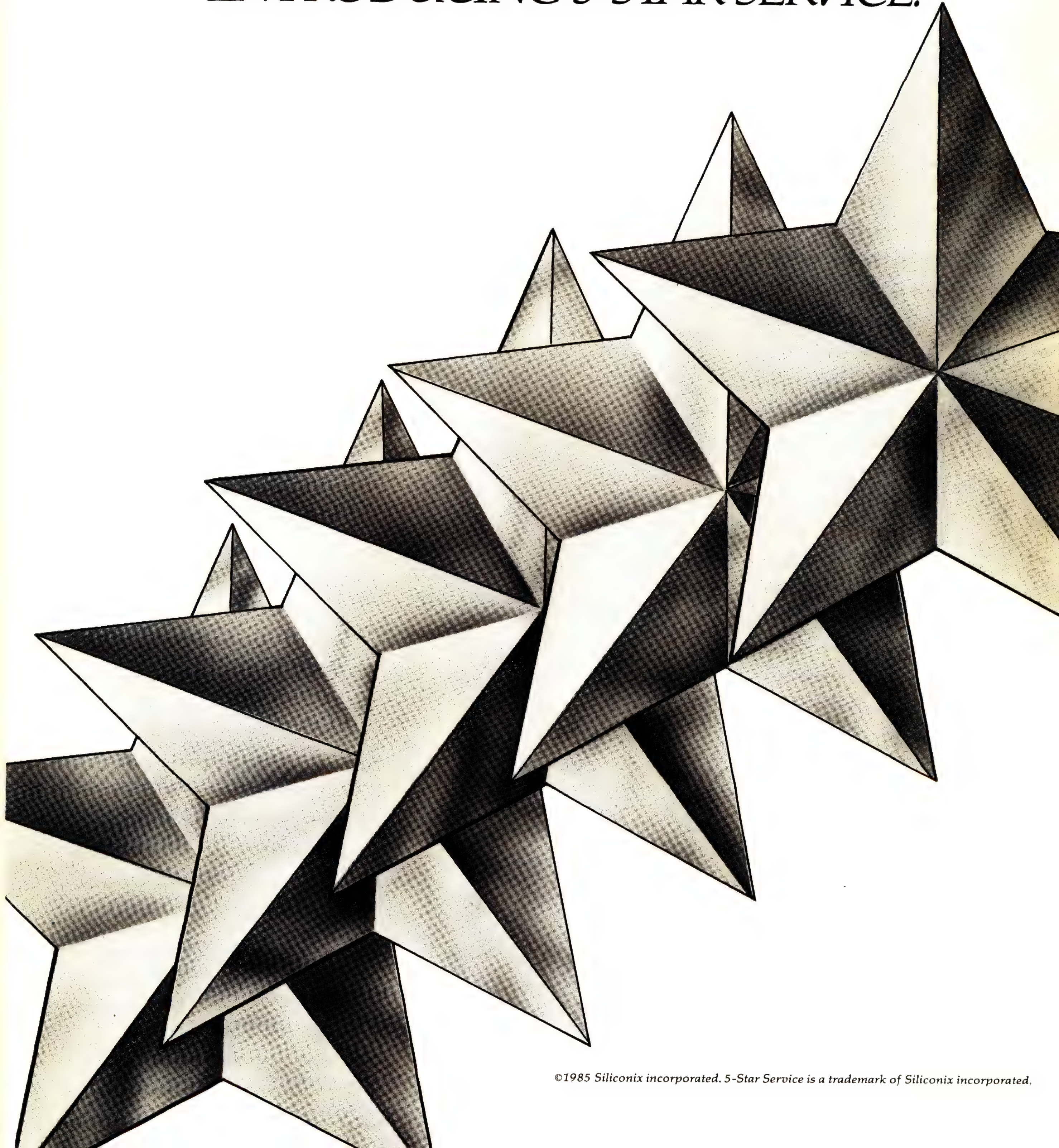
INTRODUCING 5-STAR SERVICE.



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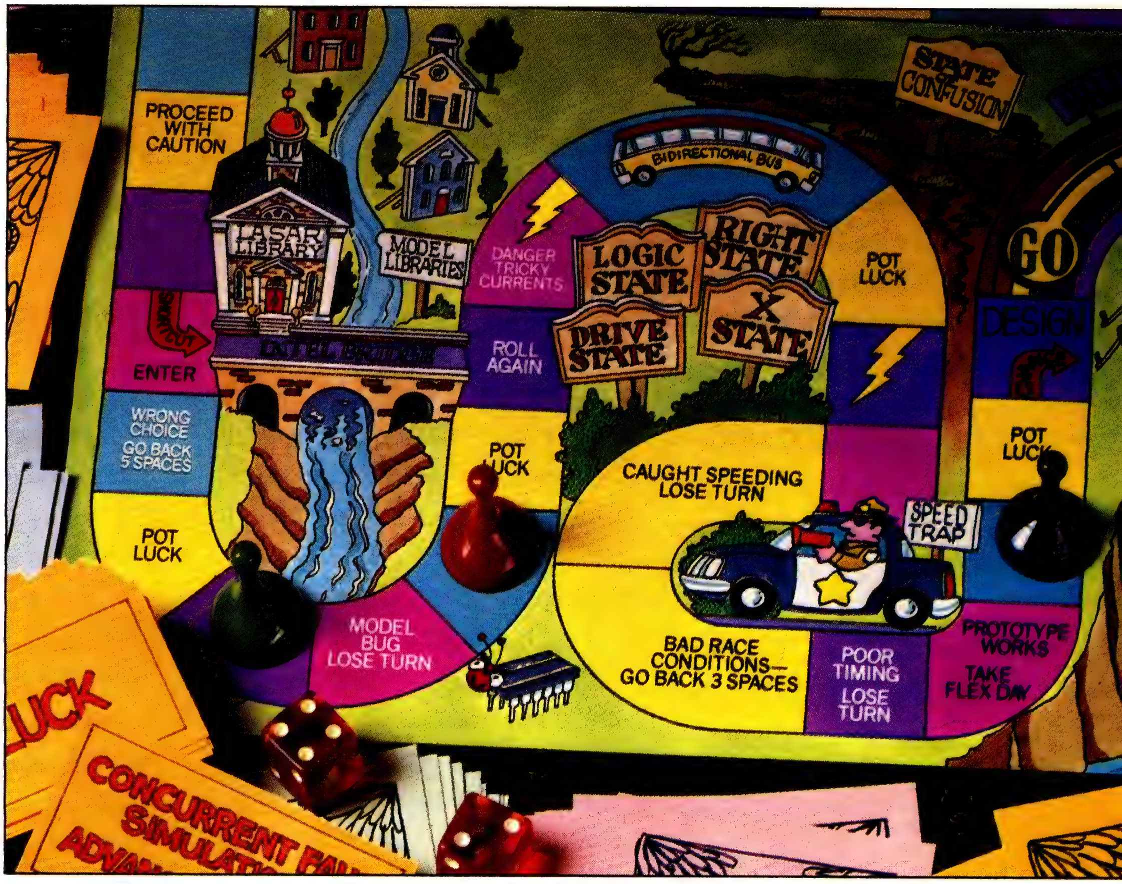
CIRCLE NO 18

Choose LASAR logic simulation and win the board game.



RULES OF PLAY:

The Simulation Game is for design engineers and CAE/CAD/ATE managers of all ages. Any number can play.

The object is to uncover design flaws in devices, boards, and systems. Verify performance. Avoid multiple prototypes. And create quality tests.

The winner will get to market fastest. And earn great profits. Ready? Let's begin.

Visiting A Model Library.

First, move your game piece and look at each simulator's model library. But watch out! Don't risk everything on library size alone.

Instead, insist on quality of information as well as quantity. Look at LASAR Version 6.

Quantity? Over 4,000 complete devices. Quality? The best. Every model is hardware verified. Functionally accurate. With manufacturers' timing specs.

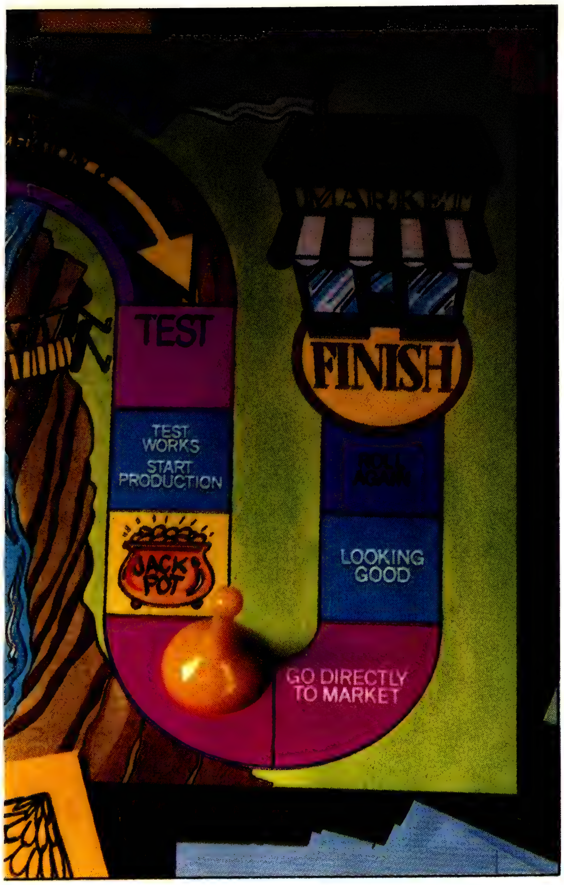
It's also the only library with the Intel Bridge: complete device models directly from Intel's design data base. Its models of parts like the 8051, 8086, 80186, and 80286 are a real shortcut for new board designs.

What's not in the library, LASAR helps you build. With behavioral and register transfer languages to model from the top down. Structural and functional primitives to build from the ground up. Combine models at any hierarchical level for true mixed mode simulation.

So, do you choose libraries with sheer volume? Or with volumes of useful information?

Avoiding States Of Confusion.

Now answer a logical question. Is the simulator with the most logic states the most accurate?



LASAR Version 6 has 15 logic simulation values. Plus min and max signal strengths for every drive state, to help you navigate tricky electrical currents around buses, wired nets, and bidirectional transfer gates. All told, equivalent to more than *one billion* states.

With one picosecond resolution, LASAR also analyzes worst-case timing. It's the only simulator that reliably predicts hazards by eliminating common timing ambiguity.

With LASAR, you always know what state you're in, regardless of circuit design or IC technology.

State the obvious. Is LASAR's simulation accuracy best? Sorry, an incorrect answer here and you end up in the wrong state.

Escaping The Speed Trap.

Proceed with caution as you compare simulation speed.

Events per second is only one clue to performance. Evaluation accuracy is the other.

LASAR simulation adds full logic and min/max timing analysis, and detailed hazard reporting, for the most complete design evaluation possible. Without any speed penalty.

New LASAR SimuLite™ verifies circuit functions three to eight times faster than other logic simulators.

And concurrent time-based fault simulation with LASAR is five to 50 times faster than the competition.

Time again to choose. Then resume speed.

Bridging The Gap Between Design And Test.

LASAR Version 6 connects CAE/CAD with ATE.

Its netlist converters translate circuit schematic data from leading CAE and CAD systems. With UNIX and VMS versions, it runs on leading workstations and minicomputers.

And LASAR comes from Teradyne. We know ATE hardware. So patterns and diagnostics move from design to prototype and production test with ease.

Others say they bridge the gap. But don't get left hanging. You'll be on firm ground with LASAR.

Winning The Game.

Simulation is not a trivial pursuit. But with LASAR Version 6 you can win the board game. Gain a monopoly on good design. And get to market fast.

Don't play around.

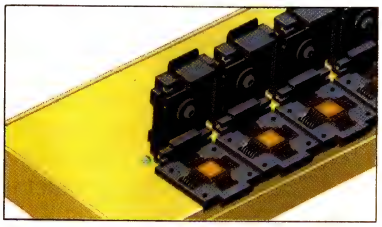
Write Teradyne,
321 Harrison Avenue, Boston,
MA 02118. Or call someone who
knows the score: Daryl Layzer,
LASAR Software Product Group,
(617) 482-2700, ext. 2808.

TERADYNE
We measure quality.

CIRCLE NO 19

Your move.

WHY BE A PAWN IN THE GAME? CHOOSE FROM THE PP40 SERIES OF GANG PROGRAMMERS.



Plug-in modules will handle leadless devices.

If you've ever felt cornered by the lack of choice in gang or set programming, Stag have the answer.

The PP40, PP41 and PP42 are stand-alone, low-cost, high speed programmers with fast programming algorithms that can meet virtually any requirement.

24 & 28-pin Eproms and EEproms can be programmed, with extensive self-test and fault-finder software built-in.

Parameter storage is non-volatile and there are bi-coloured 'Socket Status' LEDs and a large 16-character alphanumeric display. Together, these enable extensive error reporting.

Plug-in modules for future hardware expansion will handle new package styles – including leadless devices.

PP40 Ideal for the production environment – robust and simple to use. Capable of programming a gang of eight devices, it'll solve all your copying problems in one single-key operation – and at a price you'll appreciate.

PP41 All of the PP40's advantages, but useable too for development purposes thanks to its built-in RAM, a powerful editor and dual RS232C I/O ports.

PP42 The top of the range. This includes the important feature of Set Programming, for design development. The 'Interlace' concept enables fast handling of 8, 16 and 32-bit data, with a 2 megabit RAM as standard.

The Stag PP40 Series. With our choice, you need look no further.

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CIRCLE NO 20

NEWS BREAKS

EDITED BY JOAN MORROW

AI SYSTEMS CONNECT TO MAINFRAMES AND MINICOMPUTERS

You can now attach an artificial-intelligence workstation to your IBM mainframe or Gould superminicomputer. The Symbolics (Cambridge, MA) SNA Facility is a communications link between the company's 3600 Series computers and IBM mainframes including the 4300, 3030, 3080, and 370 Series. Symbolic-processing programs on the 3600 computers can access data on the mainframe over the link. New installation of hardware and software for both computers on the link costs $17,900; you can add more computers for $4900 per system. A similar product, the $36,000 Bus Link from Flavors Technology (Amherst, NH), connects the Lambda symbolic computer from Lisp Machine Inc to Gould superminicomputers. The 32-bit asynchronous link allows the two machines to share a portion of the supermini's memory to run symbolic-processing programs.—David Smith

AUTOMATED PC-BOARD ROUTER GIVES ECL TRACES SPECIAL TREATMENT

An enhanced router for all of Cadnetix's (Boulder, CO, (303) 444-8075) CAD and CAE workstations gives ECL connections special treatment by allowing you to specify net ordering as well as source and termination points for the trace in the schematic editor. Normally, the router uses pin- and gate-swapping techniques to minimize trace length and complexity, but the ECL designation overrides these optimizations. You can also specify maximum allowable stub length for the ECL signal to control the amount of shared copper. The automatic router wires ECL-designated nodes in the specified order. You can use a rats-nest display of the specified route sequence for signals that you manually route. The enhanced router will be shipped on all systems by the end of the second quarter and at the same time will be available as a no-charge upgrade for existing customers.—Steven H Leibson

WORKSTATION CAN ANALYZE 250,000-GATE LOGIC DESIGNS

In addition to an event-driven logic simulator, Aida's (Santa Clara, CA) Design System features a compiled-code logic simulator that generates a functional description of a logic diagram. The logic simulator then needs to analyze only the functional model of the circuit, instead of running test vectors through a series of gates during each event. A hardware accelerator increases the speed of the compiled-code simulator to 5,000,000 gates per second.

When you enter a schematic into the Design System, you can specify design rules, such as the number of gates that can be connected to a driver, and the system can enforce those rules. In addition, the package features an automatic test-pattern generator that can achieve 100% test coverage for level-sensitive scan designs. The Design System, which runs on Apollo workstations, costs $140,000; Apollo owners can add the package to their workstations for $85,000. (For information on other accelerated CAE systems, see pg 63.)—Eva Freeman

IC DESIGN KIT SUPPORTS LOW-COST PROTOTYPING

If you use the CMOS 3 standard-cell library to design a semicustom IC, you can take advantage of the low-cost prototype fabrication offered by the University of Southern California's Information Sciences Institute. The fabrication service, called MOSIS (MOS Implementation System), combines prototype designs from several sources onto one wafer, thereby splitting the wafer's fabrication costs among those sources. Prototype costs range from $3500 to $10,400, depending on the size of the design. The $400 CMOS 3 library from Mentor Graphics (Beaverton, OR) works with the company's CAE software that runs on Apollo workstations.—David Smith

NEWS BREAKS

SILICON COMPILATION COMES TO ENGINEERING WORKSTATIONS

Silicon Compilers (San Jose, CA) offers its Genesil 100 Silicon Development system for Apollo color workstations, including the recently announced DN570. For the MicroVAX II, you can run either the Genesil 100 system, the 2-user Genesil 200 system, or the $75,000 Generator Development Tools software from Silicon Design Labs (Liberty Corner, NJ). The Genesil 100 for an Apollo workstation costs $132,000 and will be available on April 15; the Genesil 200 costs $295,000.—David Smith

VLSI CHIPS SIMPLIFY ISDN SYSTEM DESIGNS

A set of four VLSI chips provides the framework for the lowest two layers of integrated services digital network (ISDN) systems that conform to the open-system interconnection (OSI) model. The four VLSI ICs from Siemens Captial Corp (Iselin, NJ, (201) 321-4540) provide communication-control, echo-cancellation, and burst-control operations as well as S-Bus interface circuits. For example, the manufacturer's ICC chip serves one or more ISDN terminals and provides two 64k-bps digital-communication channels and one message-oriented 16k-bps channel. Siemens also offers a fifth chip—the SAB-82520 ISDN high-level communication controller—which supplies two full-duplex HDLC communication channels. The chip includes telecommunication-specific features, such as time-slot assignment, that let it handle packet-switched data on ISDN subscriber line interface cards. Prices for the chips start at $16 (1000).—Jon Titus

2-μm STANDARD-CELL LIBRARY BOASTS 40-MHz CLOCK RATES

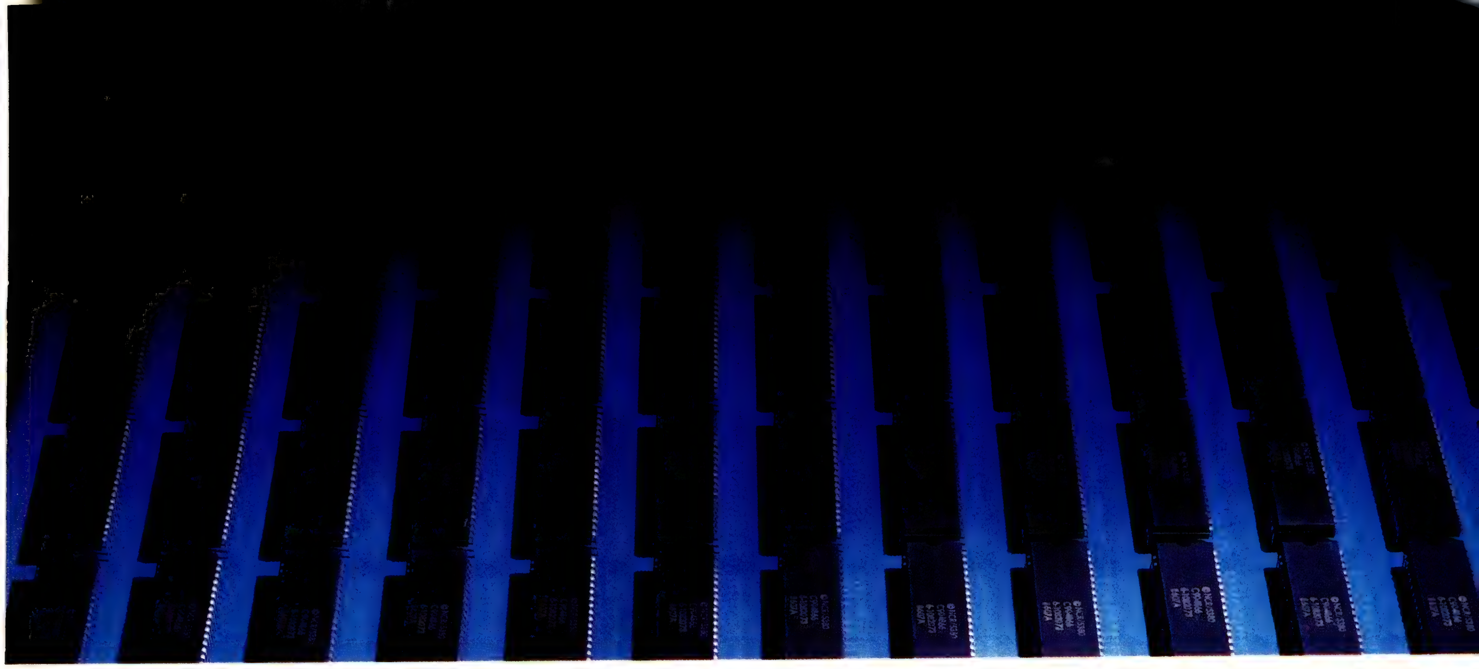
NCR Corp Microelectronics Div's (Dayton, OH, (303) 226-9500) 2-μ standard-cell library, which supports a CMOS double-level metal technology, forms the foundation of a library of standard cells shared by NCR and Motorola Semiconductor Products. The library provides users with an upgrade path from NCR's 3-μ product line. The new library allows unrestricted clock rates of 30 MHz and restricted rates to 40 MHz. Packaging options include pin-grid arrays and surface-mount devices.—Maury Wright

1.4-nSEC CMOS ARRAYS OFFER RAM AND ROM

Three families of CMOS arrays from Fujitsu Microelectronics (Santa Clara, CA) offer gate delays of 1.4 nsec, gate densities as high as 8000 gates, and on-chip RAM and ROM. Arrays in the AVM family offer 1k to 2k bits of RAM with an access time as low as 26 nsec (access time depends on memory size and configuration). Between 2k and 4k bits of ROM are also included on AVM arrays. The AVB family of arrays integrates as many as 2052 gates and drives 10-mA signals. The AV family includes arrays with gate densities from 2640 to 8000 gates. Prices for production devices are less than $0.005 per gate, depending on device complexity and packaging. Turnaround time is seven weeks typ.—David Smith

ERASABLE CMOS PLD REPLACES 22V10-TYPE PLDs

You can replace bipolar 22V10 PLDs with the CMOS PAL C 22V10 from Cypress Semiconductor (San Jose, CA) and take advantage of the CMOS part's reprogrammability and lower power consumption. It matches the timing parameters of AMD's Am22V10A but consumes 80 mA vs the bipolar part's 180 mA. It can replace 10 other 24-pin PLDs as well: 20L10, 20L8, 20R8, 20R6, 20R4, 12L10, 14L8, 16L6, 18L4, and 20L2. You reprogram the PAL C 22V10 under an ultraviolet lamp, allowing you to change your design or to use the part in another system. Commercial chips in plastic DIPs cost $28.35; military versions in ceramic DIPs cost $72 (100).—David Smith



THE MAKINGS OF A SCSI REPUTATION.

Product announcements do not a SCSI chip make. Over the years, NCR has cultivated a SCSI reputation by delivering chips. Not promises.

To date, hundreds of host and peripheral manufacturers have committed designs to our SCSI chips. We like to think that's because NCR expertise played an instrumental role defining the ANSI X3T9.2 standard from the start.

Or maybe more manufacturers design our SCSI single-chip controllers into hosts, printers, tape drives, rigid and optical disks because of the breadth of our product line.

Or perhaps it's a compatibility issue. The fact that NCR SCSI chips assure plug compatibility with hosts and peripherals regardless of manufacturer.

Or a real estate issue. The fact that NCR offers the system integrator single-chip solutions that replace multiple chips or boards.

But probably the biggest reason more companies rely on NCR SCSI chips is availability. We actually have product on the shelves. Here and now.

5385E — Full protocol integration, highest performance family member—48 pin package
5380 — Single-ended bus transceivers included—40 pin package; CMOS available
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5386S — Synchronous superset of 5385E which provides parity through the chip—samples available.

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CIRCLE NO 21

NEWS BREAKS: INTERNATIONAL

EDITED BY JOAN MORROW

3-IN. FLOPPY-DISK DRIVE WEIGHS 250g

A 3-in. floppy-disk drive from Matsushita Electric Components Co weighs just 250g and measures 90×29×65 mm—only slighter larger than a pack of cigarettes. Disk capacities come in three sizes: 1M, 500k, and 250k bytes. The device requires 1.9W and operates on a 4.5 to 6V battery. Data-transfer speed for the 1-head drive equals 250k bps and disk rotation is 300 rpm, thus allowing a 5¼-in. drive's controller to be used in the miniature drive. Matsushita has not yet determined pricing.

GaAs LOGIC ICS ARE ECL COMPATIBLE

Three GaAs logic ICs from Nippon Electric Co include a master/slave D-type flip-flop (the MuPG700), a master/slave T-type flip-flop (the MuPG701), and a 3-input OR/NOR gate (the MuPG702). The devices' −0.8 to −1.8V I/O levels and −5.2V power-supply voltage make them compatible and connectible to ECL devices. The ICs feature a clock frequency greater than 2 GHz, a pulse rise time of 130 psec, and a decline time of 120 psec. They use air-bridge interconnect technology and come in heremeticaly sealed 16-pin ceramic packages. Samples are available for ¥ 48,000 ($253) each. NEC plans to sell the devices to manufacturers of measuring instruments and VLSI testers. The company also plans to introduce six more GaAs standard logic devices before this summer.

32-BIT MICROPROCESSOR CAN PERFORM 6 MIPS

Matsushita Electric Industrial Co's 32-bit microprocessor performs 6 MIPS (1M flops). The company developed the CMOS-type device, which integrates approximately 400,000 elements, using a 1-μm design rule. Its clock frequency is 25 MHz. Evaluation samples should be available in the fall. Other Japanese companies that are working on 32-bit μPs include NEC and Hitachi.

GATE ARRAY FEATURES BUILT-IN AUTOMATIC FUNCTION

Two CMOS gate arrays in the HG62B Series from Hitachi Ltd, a 4032-gate device and a 7136-gate array, furnish a built-in memory that can detect flaws within the microcircuit. This feature reduces the design time and allows a user to design a circuit without being concerned about making errors. The arrays also provide a 1.8-nsec gate delay. The 4032-gate device costs ¥ 2300 ($12) and the 7136-gate version costs $68. Hitachi is also working on a 12,000-gate array.

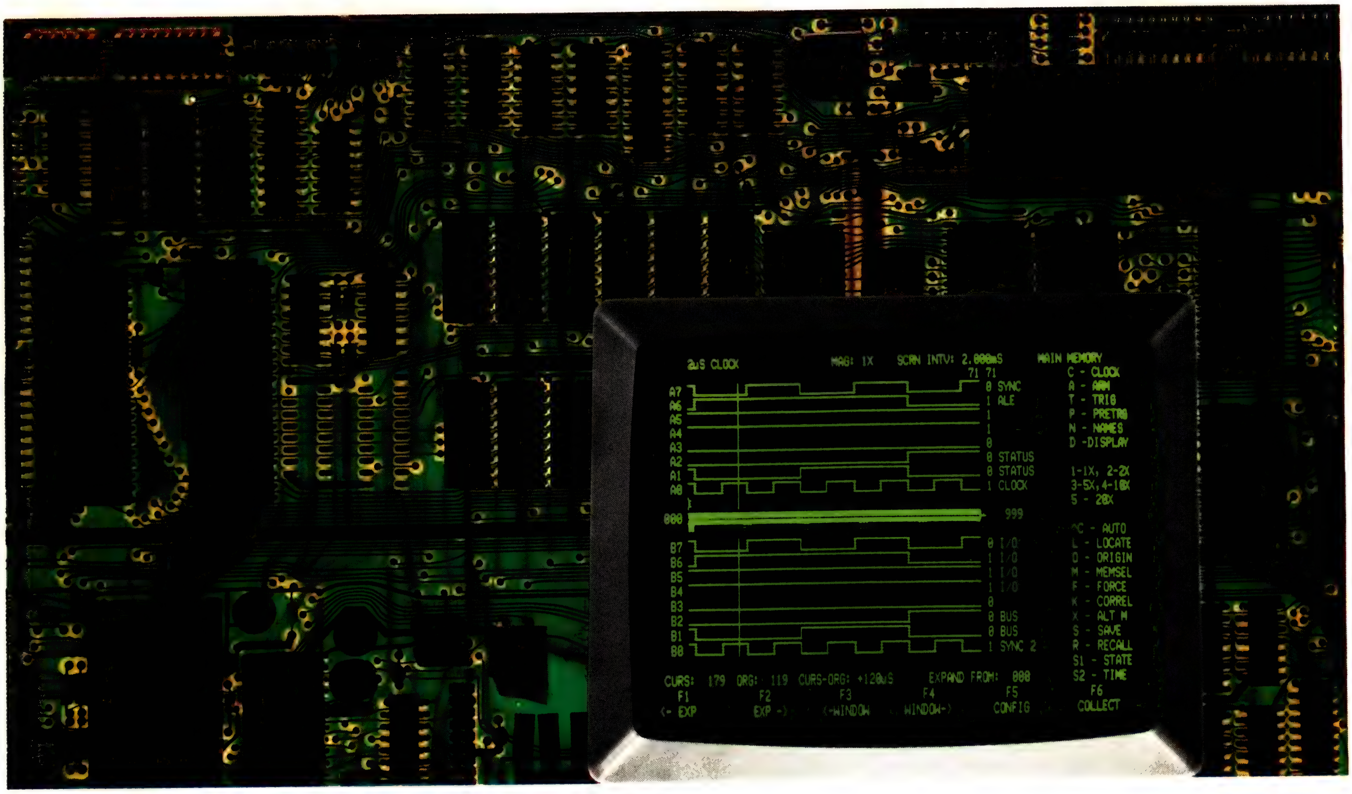
1M-BIT MASK ROM DISSIPATES 165 mW

The M5M23C100P 1M-bit mask ROM from Mitsubishi Electric Corp features a dissipation rate of 165 mW during operation and 550 μW at standby. Access time for the CMOS device is 250 nsec. Housed in a 28-pin DIP, the device costs ¥ 2500 ($13.15) in samples. Mitsubishi plans to produce 50,000 chips per month.

RESIN DEVELOPED FOR ERASABLE OPTICAL DISKS

Sumitomo Chemical Co has developed a new type of resin that could lead to the development of erasable optical disks. The resin almost eliminates double refraction, which has been the major problem in these disks' development. The company combined two types of resin with opposite double-refraction characteristics, which allows the positive refraction factor of one resin to neutralize the negative factor of the other. Sumitomo claims that, with a few improvements, it can commercialize the resin in about 10 months.

THE TOTAL LOGIC ANALYSIS SYSTEM



THE LOGICAL SOLUTION.

It makes perfect sense.

Think about it. 48 channels of state analysis, full analog capability, and powerful 200 MHz timing analysis where it counts—on all 16 timing channels. Time and event histograms to monitor software performance. Dual floppy disk drives, special I/O software, IEEE-488 controller and RS-232 Master/Slave operation to enhance your development and trouble-shooting efficiency. A general purpose computer, with a CP/M operating system. The 800 gives you all this and more in one instrument.

Easy to operate.

In fact, you probably already know how to use it. All the functions and options are accessed and controlled through a familiar ASCII keyboard. And all of the 800 Series configurations are modular. That makes expansion easy and cost effective.

The logical solution.

Before you make any decisions about your next logic analyzer, you owe it to yourself to take a close look at the Nicolet 800 Series. Call us today at 608/273-5008. Or write Nicolet Test Instruments Group, P.O. Box 4228, 5225 Verona Road, Madison, WI 53711-0288.

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CIRCLE NO 22

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Check these features:

- ✓ Each unit undergoes high-impact shock test
- ✓ Available from 1 to 40 dB
- ✓ DC to 1500 MHz
- ✓ Unexcelled temperature stability, .002 dB/°C
- ✓ 2W max. input power (SMA is 0.5W)
- ✓ BNC, SMA, N and TNC models
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NEW!

Precision 50-ohm terminations... only $6.95 (1-24)
DC to 2 GHz, 0.25W power rating, VSWR less than 1.1
BNC (model BTRM-50), TNC (model TTRM-50)
SMA (model STRM-50), N (model NTRM-50)

*Freq. (MHz)	Atten. Tol. (Typ.)	Atten. Change, (Typ.) over Freq. Range		VSWR (Max.)	
		DC–1000	1000–1500	DC–1000 MHz	1000–1500 MHz
DC-1500 MHz	±0.3	0.6	0.8	1.3	1.5

*DC–1000 MHz (all 75 ohm or 30 dB models) DC-500 MHz (all 40 dB models)

MODEL AVAILABILITY

Model no. = a series suffix and dash number of attenuation.
Example: CAT-3 is CAT series, 3 dB attenuation.
■ denotes 75 ohms; add −75 to model no.
● denotes 50 ohms

ATTEN	SAT (SMA)	CAT (BNC)	NAT (N)	TAT (TNC)
1	●	●	●	●
2	●	●	●	●
3	●	●■	●	●
4	●	●	●	●
5	●	●	●	●
6	●	●■	●	●
7	●	●	●	●
8	●	●	●	●
9	●	●	●	●
10	●	●■	●	●
12	●	●	●	●
15	●	●■	●	●
20	●	●■	●	●
30	●	●	●	●
40	●	●	●	●

PRICING (1-49 qty.): CAT (BNC)..$11.95, SAT (SMA)..$14.95
TAT (TNC)..$12.95, NAT (N)..$15.95

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SPECIFICATIONS for
PSW 1111 (SPST) **and PSW 1211** (SPDT)
ZMSW 1111 and ZMSW 1211

FREQUENCY RANGE	10-2500 MHz
INSERTION LOSS	
10-2000 MHz	1.7 dB max.
2000-2500 MHz	2.7 dB max.
ISOLATION	
10-500 MHz	40 dB min.
500-1000 MHz	30 dB min.
1000-2000 MHz	25 dB min.
2000-2500 MHz	20 dB min.
SWR	1.5 max. ("on" state)
SWITCHING SPEED	1 μsec. (max.)
MAXIMUM RF INPUT	+20 dBm
CONTROL	+5 V (5 mA max.)
OPERATING TEMPERATURE	−54°C to +100°C
STORAGE TEMPERATURE	−54°C to +100°C

PRICE (6-24)		(1-4)	
PSW 1111	\$29.95	ZMSW 1111	\$59.95
PSW 1211	\$29.95	ZMSW 1211	\$59.95

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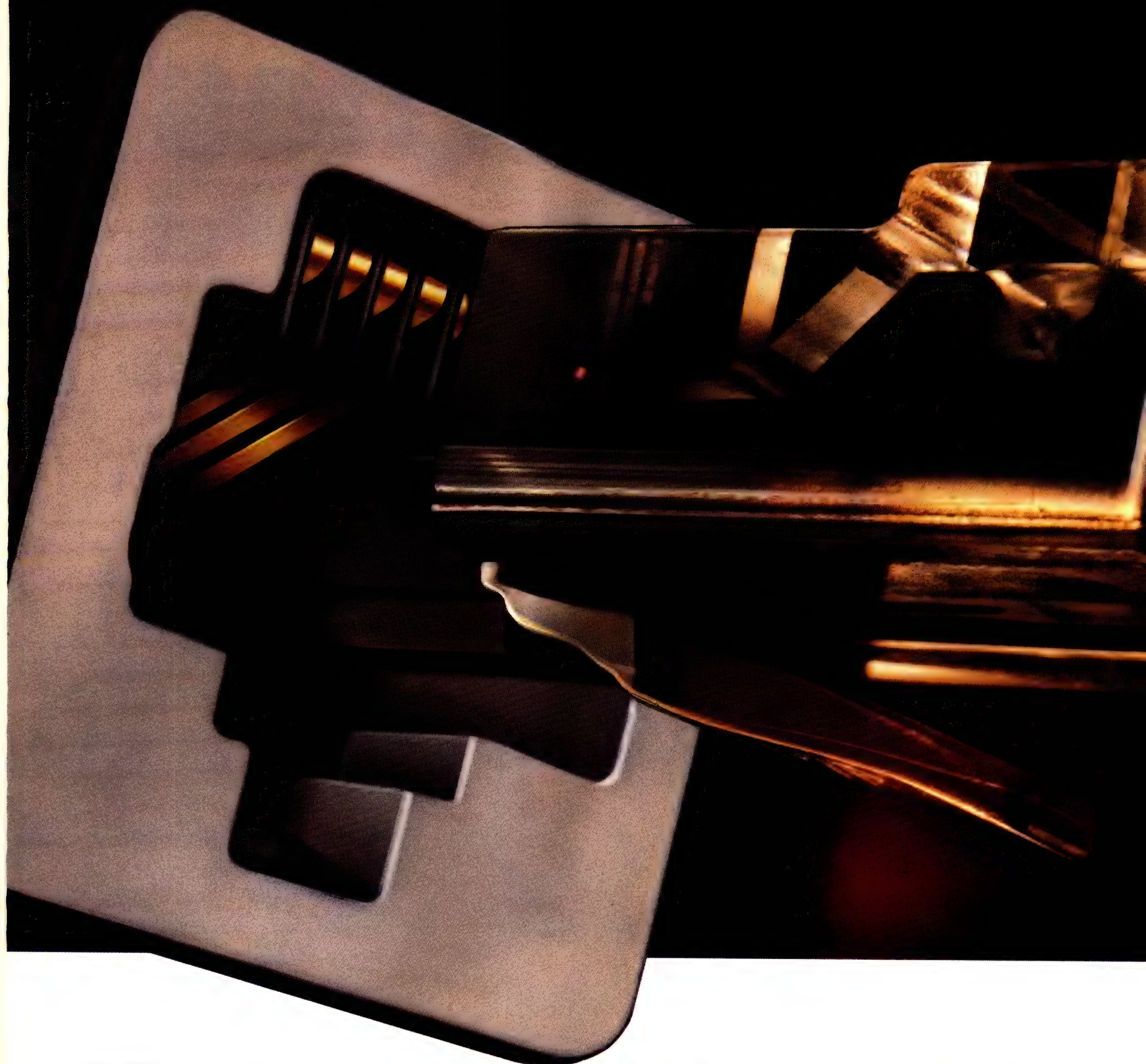
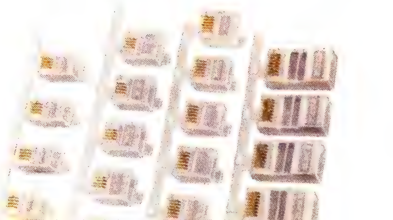
CIRCLE NO 23



The latest word in modular plugs and jacks. And the same solid story of savings.

AMP modular plugs in strip form for termination with high-speed application tooling.



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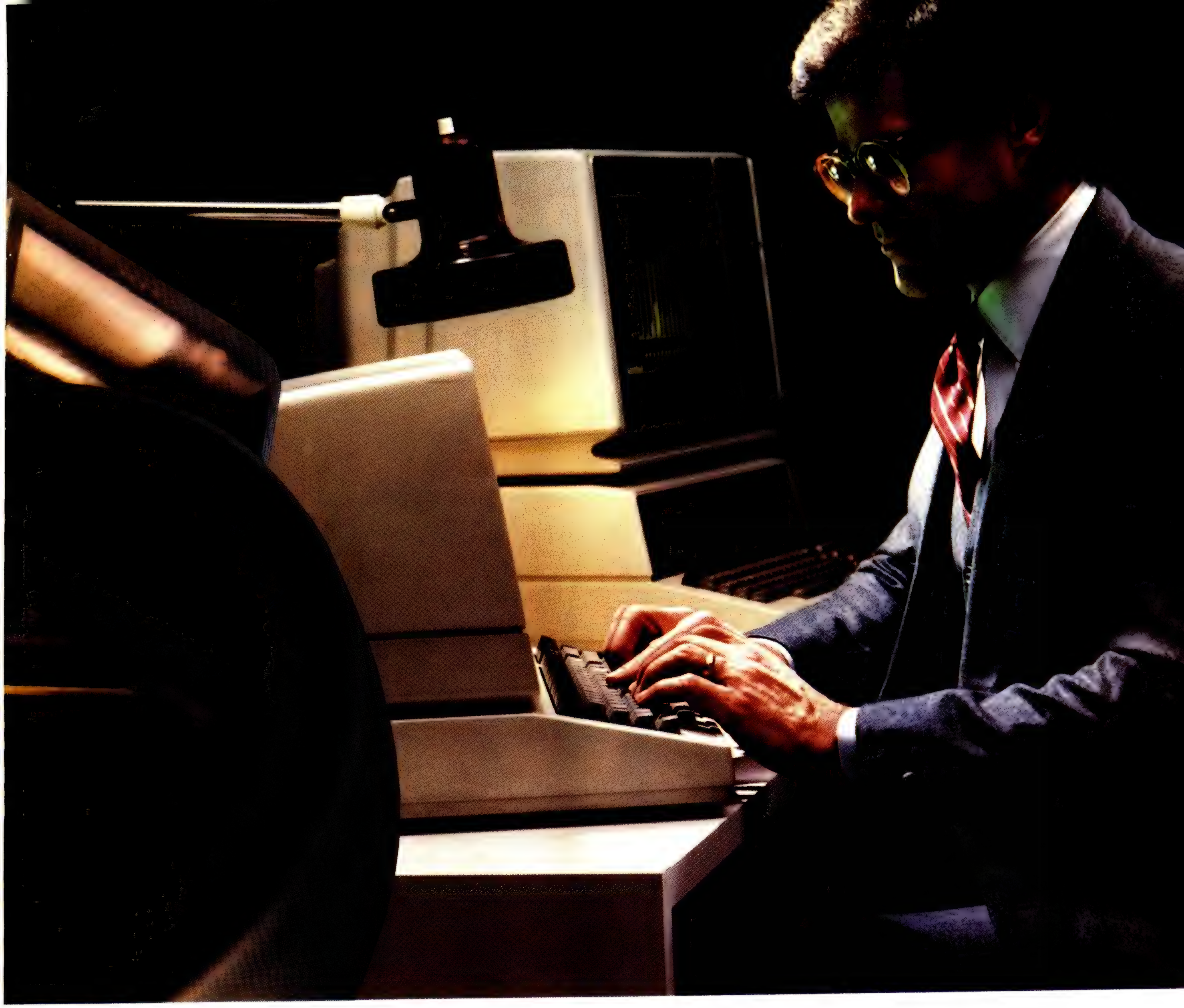


The popularity and wide acceptance of modular plug design make it especially appealing for I/O. Now, get the low applied cost and tooling support you need to make the most of it.

Our pre-loaded plugs mass terminate (with double strain relief) round or flat-oval wire, tinsel or stranded conductors. Top- and side-entry jacks simplify pcb design. And our selective gold contacts offer long life while trimming costs.

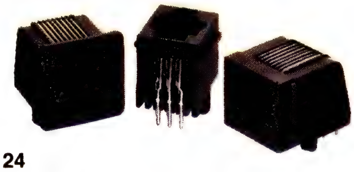
Our production hand tool is simply the best of its kind anywhere. We also offer a low-cost field/prototype tool, as well as benchtop or high-speed application machinery for the production rate you want, and the benefits you need.

Low cost and high productivity. From AMP.

Call (717) 780-4400 for more information. Ask for the AMP Modular Interconnection Desk. AMP Incorporated, Harrisburg, PA 17105-3608.

AMP Interconnecting ideas

Our modular plug production hand tool cuts cable, strips cable jacket and mass terminates loose piece plugs.



AMP modular jacks are U.L. listed. In top-entry and flanged or flangeless side-entry versions.

CIRCLE NO 24

MIL-STD-1553

Taking the best products and making them BETTER...

1

ARX 18553 Miniature Transceiver

The world's smallest transceiver for use in MIL-STD-1553A and B data transmission systems. It includes all the features characteristic of other Aeroflex transceivers in a hermetically sealed 18 pin double DIP case.

2

ARX 2432 Remote Terminal Unit

A complete dual redundant MIL-STD-1553B remote terminal (RTU) in a 2.1 by 1.9 in. hybrid package. It includes dual transceivers, wrap around test capability, handles all mode codes plus broadcast and interfaces to subsystem via bidirectional 32 word FIFO memory.

3

ARX 1555LP Bit Processor

Low power version of ARX 1555 Bit Processor provides improved response times, higher reliability and lower power consumption without reduction in digital load driving capability. Features encoder, decoder, wrap around self-test capability, fail safe time out and address recognition.

4

ARX 3232 Multi-Bus Transceiver

Suitable for use in McDonnell Douglas (MACAIR) data transmissions systems as well as MIL-STD-1553A and B. Enhancements include active filter in driver for sinusoid waveform, high efficiency low power consumption voltage output driver, vey low dynamic offset and low differential phase delay.

5

ARX 8553 Transceiver

Our worldwide best seller is suitable for MIL-STD-1553A and B data transmission systems. Receiver has multipole low pass filter to enhance S/N ratio and tight threshold control to meet noise test requirements. The high efficiency driver consumes less power.

6

ARX 28553 Dual Redundant Transceiver

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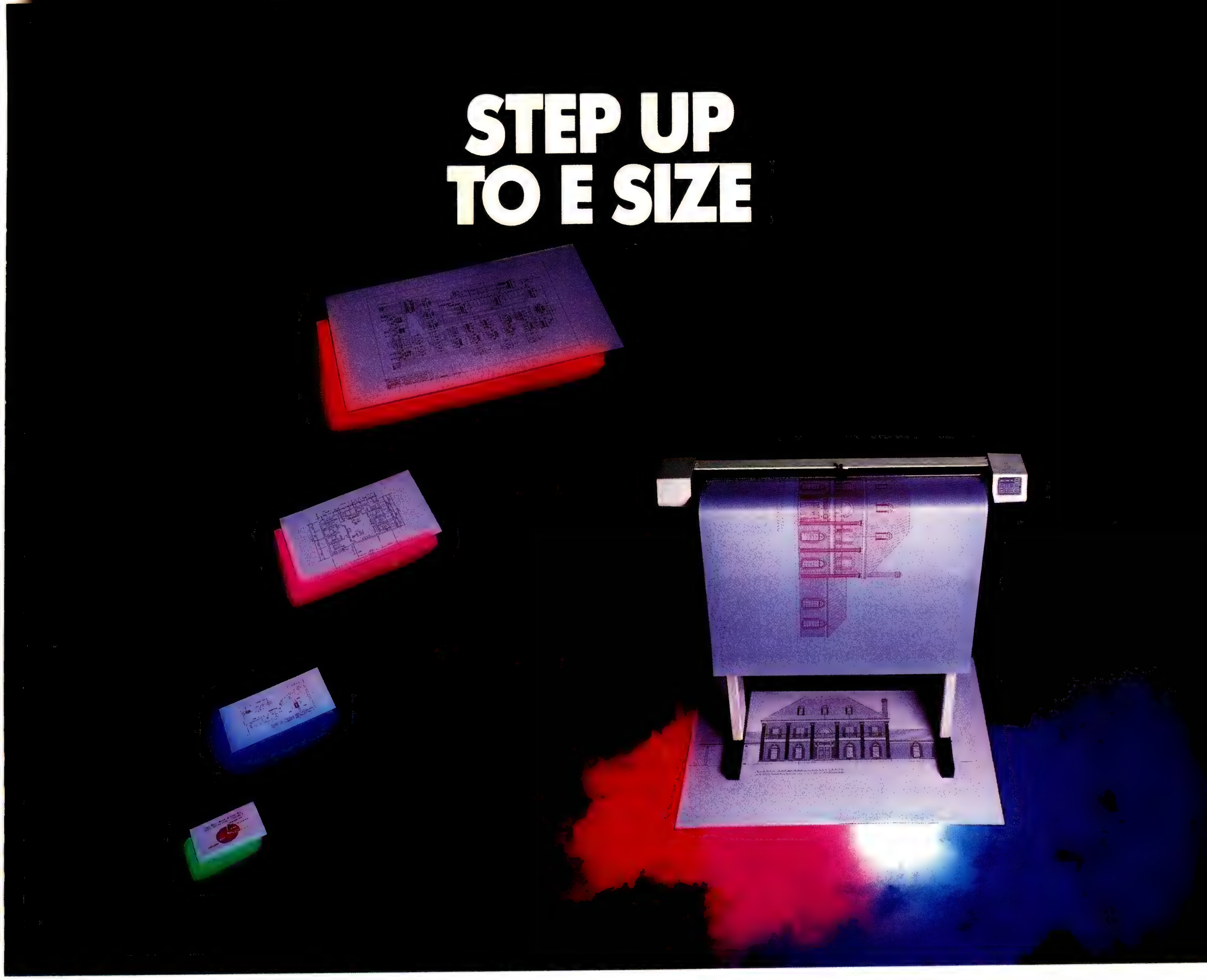
CIRCLE NO 89



Houston Instrument's new E size DMP-56 delivers the precision, throughput, and reliability you require from a drafting-intensive plotter. The DMP-56 also gives you the flexibility to handle 18 different drawing format sizes ranging from 8½ × 11 inches to 36 × 48 inches.

The DMP-56 was designed for any application calling for crisp, clean graphics—whether it's architectural floorplans, mechanical designs, electrical schematics, or overhead transparencies. Because of its media-size adjustment mechanism and automatic media-size sensing feature, the DMP-56 quickly and efficiently responds to your changing format requirements. This high-performance plotter can produce standard (A through E), metric (A4 through A0), oversize (A4 through A0), and Architectural C, D, and E drawings.

The DMP-56 is a professional drafting plotter that draws on the established track record of Houston Instrument's very successful DMP-51/52 and DMP-51/52 MP plotters—plotters that redefined the standard for price, performance, and quality.

Immediately compatible with hundreds of computer-aided design and graphics software packages through our powerful DM/PL™ command language, the DMP-56 also gives you a precise resolution of .001 inch and a maximum plotting speed of 17 inches per second. And, because it uses a standard RS-232-C compatible interface, the DMP-56 can operate with virtually any computer on the market.

The DMP-56 also delivers features you'd expect only from more expensive* plotters—such as quiet servo drive, and an easy-to-use front-panel control. Combine these standard features with the well-known Houston Instrument reliability and support and you have a superior plotter at a reasonable price.

In terms of throughput, performance, price, and quality the DMP-56 is the professional graphics tool you need. For more information, call 1-800-531-5205 (512-835-0900 if in Texas), or write Houston Instrument, 8500 Cameron Road, Austin, Texas 78753. In Europe, contact Houston Instrument, Belgium NV., Rochesterlaan 6, 8240 Gistel, Belgium. Tel.: 32-(0)59-277445. Tlx.: 846-81399.

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CIRCLE NO 133

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SIGNALS & NOISE

Part-time inventing isn't worth the hassle

Dear Editor:

Deborah Asbrand's article, "Engineers who double as part-time inventors face full-time obstacles in the process" (EDN, October 3, 1985, pg 265), has grabbed me by the collar and compelled me to write to you. I didn't realize that there was a soul in our US government who cared about the interests of inventors/engineers or the contributions they can make to the nation.

Over the past 12 years, I have developed five US and foreign patents, all of which were assigned to the company I work for—as they should be, because they were developed at company risk and expense. It was not until I developed a new device at home—a device unrelated to my company's products—that I ran into the problems that Ms Asbrand described. The details of the battle that ensued are unimportant; it suffices to say that I paid my attorney's fees, obtained both a release from my company to pursue the product and a nasty letter to my personnel file, sold the invention to a would-be competitor for a nice profit, and quit inventing. It's just not worth the hassle.

The irony of all this is that a year later I was promoted to engineering manager with this same company, which places such a premium on inventions. Am I now an inventor/engineering manager? Preposterous! For stifling creativity, a manager's office is second only to the steps of a gallows.

In her article, Ms Asbrand observed that the preinvention assignment agreement encourages the inventor to closet ideas not related to his company's business until he changes jobs. I think the corollary to her statement is that such an agreement weighs heavily in an inventor's decision to change employment.

As for me, I won't work on another invention at home unless I join a different firm. Then, if I'm lucky, a number of good ideas may come to mind so I can list them as exclusions. If I were to have a good idea now, the risk I'd take in requesting a release from my present company would be too great, and I would be looked upon as disloyal and selfish, as someone not interested in putting every effort into promoting the company.

Management skills, unlike inventing skills, may be openly traded. For instance, if I had the business skills of our president, I might sit on outside boards of directors or, as another of our managers has done, I might start a restaurant. No agreements exist to limit any activity except inventing.

My desire to create is insatiable, but I have found that it can be steered in directions that are safe from the grasp of preinvention agreements, at least for now. To satisfy my creative propensity, I'm working on a couple of novels. Move over, please, because this inventor wants to join your ranks.

Name withheld upon request

Inventors are a crucial part of US productivity

Dear Editor:

I had a mixed reaction to Otto Bismarck's letter concerning employee inventions (EDN, January 23, pg 30), for he is both correct and incorrect. His fundamental premise—that patents are a tough route to prosperity—is correct. However, some of his conclusions and recommendations are incorrect.

The most glaring error is a common one: Mr Bismarck speaks repeatedly of patents rather than inventions. Although one presupposes the other, patents and inventions are not the same. A patent represents the highest status that an invention can attain. Nonetheless, the wheels of progress turn largely on the immeasurably greater quantity

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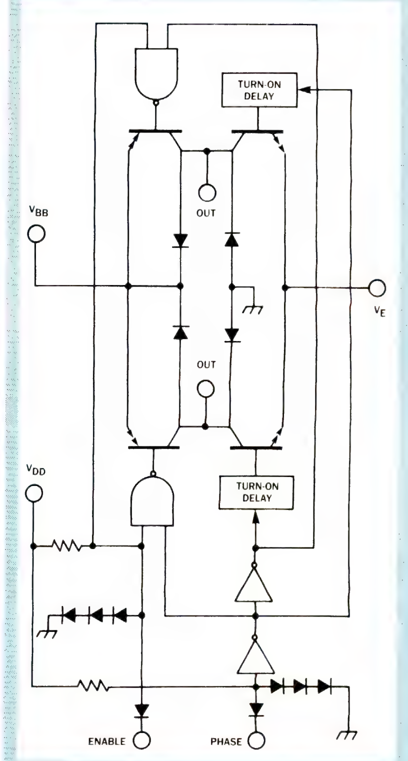

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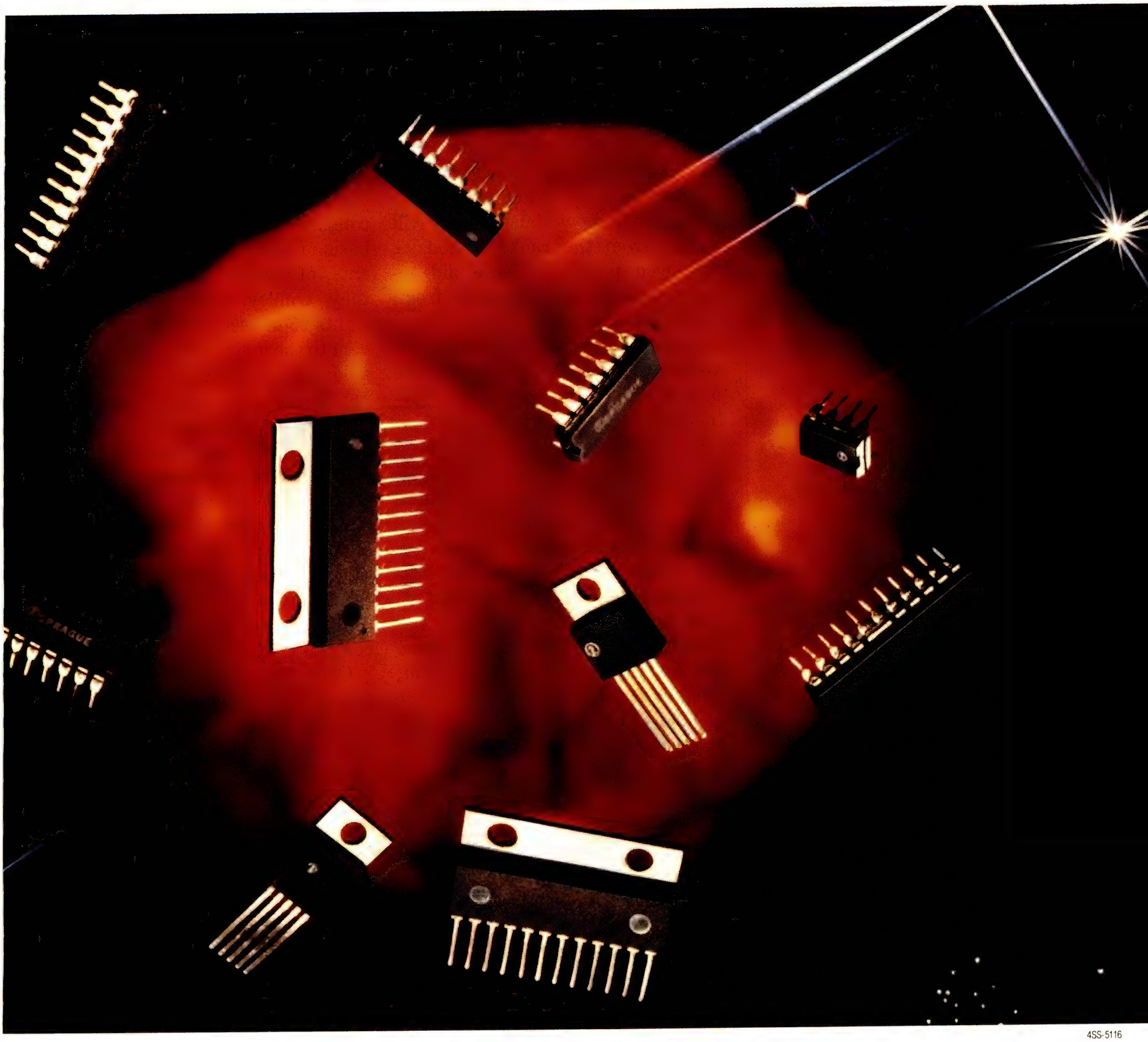

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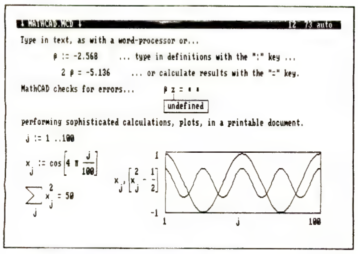

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CIRCLE NO 28

of unpatented inventions that employees create both on the job and at home.

Mr Bismarck's comments regarding the relative merits of large and small companies are especially egregious. The formation of new businesses is crucial to American innovation and productivity, and tomorrow's new businesses will spring from the ranks of today's employed people. (Where did today's large employers come from, anyway?)

Employees who sign unfair preinvention assignment agreements are unreasonably restricted from leaving their employers to create their own companies. The expected course of events is for an employee to have a really great idea, realize that his own employer cannot or will not put the idea to use, and leave in the hope of creating the next IBM. Patents are rarely involved, but inventions are. If an employee has signed away all rights to everything he invents during employment, what can he do? Should he leave the company first, and then get an idea? Some employees do, but some companies claim rights even to things created after the period of employment.

Almost universally, companies show employees the agreement forms after the employees have started their jobs, so they have no chance to refuse to sign or to look for jobs elsewhere. My advice is to get a copy of a company's agreement form before you accept any job offer. Most companies will show you the forms if you ask. Stay far away from any company that's reluctant.

The disdain Mr Bismarck shows for start-up companies is misplaced. Small businesses are far more efficient, innovative, and productive than large businesses. Over the past decade, small businesses have provided the majority of new jobs, while, over the same period, large corporations have registered a slight decline in employment. New businesses are far more productive in terms of patents issued per employee, and they also lead in other indices of innovation. On the other hand, large businesses benefit from economies of scale and from their ability to handle large, complex projects.

I applaud Mr Bismarck's call for companies to share royalties (on the basis of inventions rather than patents, of course) with the inventors they employ. His proposal that rights to unused patents should revert to the inventor is likewise laudable; engineers *should* try negotiating for this at job interviews.

However, I dispute his claim that an engineer's professional status and salary can adequately reflect "patents signed away." That's nice if you run in the middle of the pack, but pathetic if you've been delivering multimillion-dollar designs. Employees who invent such products usually leave to found their own companies.

Corporations drive out their best and brightest employees because they fail to extend to employees the free-market principles they espouse for each other. The ability of employees to leave a company and still retain reasonable rights to their inventions represents the ultimate triumph of those principles. It reminds me of an observation somebody once made about the futility of putting new wine in old bottles.

Sincerely yours,
Orin Laney
Chairman, IEEE Intellectual Property Committee
Yorba Linda, CA

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

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Part No.	Type	Max. Multiply Time (ns)	Power (mW)	Equivalent
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LMU557/558	8 x 8 mixed	60	70	25S557/8
LMU12	12 x 12	65	100	MPY12HJ
LMU13	12 x 12 microprogrammable	65	100	–
LMU16	16 x 16	80	125	MPY16HJ; AM29516
LMU17	16 x 16 microprogrammable	80	125	AM29517
LMU18	16 x 16 32-bit output	80	150	–
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LMA1009	12 x 12	65	100	TDC1009
LMA1010	16 x 16	90	100	TDC1010
LMA1043	16 x 16	90	100	TDC1043
PIPELINE REGISTERS				
Part No.	Type	Max. Access Time (ns)	Power (mW)	Equivalent
L29C520/521	4 x 8 bit	22	50	AM29520/521
LPR520/21	4 x 16 bit	22	50	two AM29520/521
MULTIPORT REGISTER FILES				
Part No.	Type	Max. Access Time (ns)	Power (mW)	Equivalent
LRF07	3 independent port, 8 x 8	35	40	–
LRF08	5 independent port, 8 x 8	35	60	–
ARITHMETIC LOGIC UNITS				
Part No.	Type	Min. Cycle Time (ns)	Power (mW)	Equivalent
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L4C381	16-bit adder/subtractor	34	75	Quad 54/74S381
SPECIAL-FUNCTION CIRCUITS				
Part No.	Type	Performance	Power (mW)	Equivalent
LSH32	32-bit barrel shifter	35 ns prop. delay	60	–
L10C23	64-bit digital correlator	35 MHz data rate	125	TDC1023J

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5100 Series Storage: 5111, 5111A, 5113, 5115, D11, D13, D15, 577/D2		C-59A	C-4 OPT02, C-5C, C-7, C-7 OPT01
5400 Series Non-storage: 5403/D40, 5440, 5444, D40		C-59A	C-4 OPT02, C-5C, C-7, C-7 OPT01
5400 Series Storage: 5403/D41, 5441, D41	C-51	C-53	C-4 OPT02, C-5C, C-7, C-7 OPT01
5223		C-59A	C-4 OPT02, C-5C, C-7, C-7 OPT01
Tek 7000 Series			
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Large Screen Display i.e.; 7403, 7603, 7603N		C-59A	C-4 OPT02 C-5C, C-5C OPT01, C-7, C-7 OPT01
Tek Portables			
Older with 0.8 cm Graticule i.e.; 422, 453, 454, 485, 491	C-31B	C-30B	C-4
Newer w/1 cm Graticule i.e.; 2235 Option 01; 2400 Series, 455, 464, 465, 465B, 465M, 466, 468, R468, 475, 475A, 432, 434, 442	C-31B OPT01	C-30B OPT01	C-4 C-7 OPT02, C-7 OPT03, C-5C OPT02, C-5C OPT04
1 cm Nonilluminated Graticule, 2213(A), 2215(A), 2220, 2230, 2235(L), 2236			C-7 OPT02, C-5C OPT04
¼ inch Graticule i.e.; 305, 314, 326, 335, 336, 1501, 1502		C-30B OPT01	C-4 OPT03
TM 500 i.e.; SC 502, SC 503, SC 504		C-30B OPT01	
Nonilluminated Graticule 2335, 2336(YA), 2337			C-7 OPT02, C-5C OPT04
Tek Display Monitors			
8 cm x 10 cm i.e.; 601, 602, 605, 606, 606B, 607		C-59A	C-4 OPT02 C-5C, C-7, C-7 OPT01
Large Screen 10 x 12 cm i.e.; 603, 604, 608, 620, 624, 634		C-59A	C-4 OPT02 C-5C, C-7, C-7 OPT01
Tek Older 5 Inch Round			
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Tek Older 5 Inch Rectangular			
560 Series i.e.; 561, 564, 567, 568		C-53	C-59A
Tek TV Products			
380, 381	C-30B OPT01		
520, 520A, 521, 521A, 522A		C-59A	
1480C		C-53	C-59A
528A, 1420, 1421, 1422, 1424		C-59A	C-4 OPT02 C-5C, C-7, C-7 OPT01
529		C-53	
1710B, 1711B, 1740, 1741, 1742, 1750		C-30B OPT01	C-4 C-7 OPT02, C-7 OPT03, C-5C OPT02, C-5C OPT04

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Tek Miscellaneous			
576, 5030, 5031		Only C-59(A)	
OF 150, OF 151, OF 152, OF 235, TDR			C-4 OPT02 C-5C, C-7, C-7 OPT01
1240			C-4 OPT11
T900 Series, excluding T922R, (see 7000 Series)			C-5C OPT03, C-7 OPT04
Hewlett Packard*			
1715A/22B/ 25A/26A/27A 1740A/41A/42A 43A/44A			C-4 C-5C OPT02;*** C-5C OPT04***
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5" rectangular CRTs: 140B/T, 141B/T 180/C/D, 181/AR/T/TR, 183/191A, 193A, 1600A, 3580A** 3720A/21A/ 90A, 3702B/12A 8412A/B 853A W/8557A/ 8558B/8559A 8754A			C-4 OPT02 C-5C (Hand held), C-5C OPT01 (Hand held), C-7 (Hand held), C-7 OPT01 (Hand held)
1200A/B, 1201B, 1205B, 1220B, 1222B			C-5C (Hand held), C-7 (Hand held)

*HP instruments without illuminated graticules which are non-storage require a C-5C or C-7 with flash. **Note: C-50 Series will not fit. ***Bezel is a little too wide for hood, i.e. a tight fit.

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5" round CRTs: 140A, 141A, 8414B/8413		C-59A	
182T, 8755S			C-4 OPT02

Oscilloscope or Display Device	TEK CAMERAS		
	High Writing Rate	General Purpose	Low Cost
B & K			
1466A/76A/ 77/79B 1500/22/25/ 35A/40/ 60/66A/ 70/70A 90/90A 96	C-31B OPT01	C30B OPT01	C-4 C-5C OPT02, C-5C OPT04
Gould*			
OS250, 260 OS1000A OS1400, 1403, 1420 OS3000/A, 3001/A, 3300B, 3350, 3351 OS4000, 4020/22/24 4030, 4035/135 4040/42/43/44			C-5C OPT04
OS4500			C-4 OPT02

*Gould instruments which do not have illuminated graticules and are non-storage require C-5C with flash.

Hameg			
HM203*/204/ 208/605/ 705/808			C-4 OPT02
*Requires C-5C or C-7 with flash.			
Hitachi			
V-134/151F*/ 152F*/202F/ 203K/211*/ 212*/222/ 223/302F*/ 352F/353F/ 422/423/ 650F/1050F 1070/1100A VC-6015/6041			C-4 OPT02 C-5C, C-5C OPT01
*Requires C-5C with flash.			
Iwatsu			
SS5321/ 5710C/D SS5702/05/06 5711/C/D 5802		C-30B OPT01	C-4 C-5C OPT02, C-5C OPT04
SS8120		C-59A	C-4 OPT02
TS8123		C-59A	C-5C, C-7, C-7 OPT01
Kikusui			
COS5020/21/ 40/41/42/ 60/60A COS5100 COS5513/16ST/ 20/30A/31 COS5630/ 50/50E COS6100/6150 DSS6520/20A/21/22	C-31B OPT01	C-30B OPT01	C-4 C-5C OPT02, C-5 OPT04
Leader			
LB051M/MV/ 513A/514A 514AP/516/ 517/518/ 522/523/524/ 524L/525L 5825/5860A			C-4 C-5C OPT02, C-5C OPT04
Philips			
PM3207/11/12/ 15/17/19 3206/32/ 33/34/62/ 63/63X 3264/66/67 3305/3310/ C/3311/C 3315 3540/42/43			C-4 C-5C OPT02 (Hand held), C-5C OPT04 (Hand held)
Takeda Riken			
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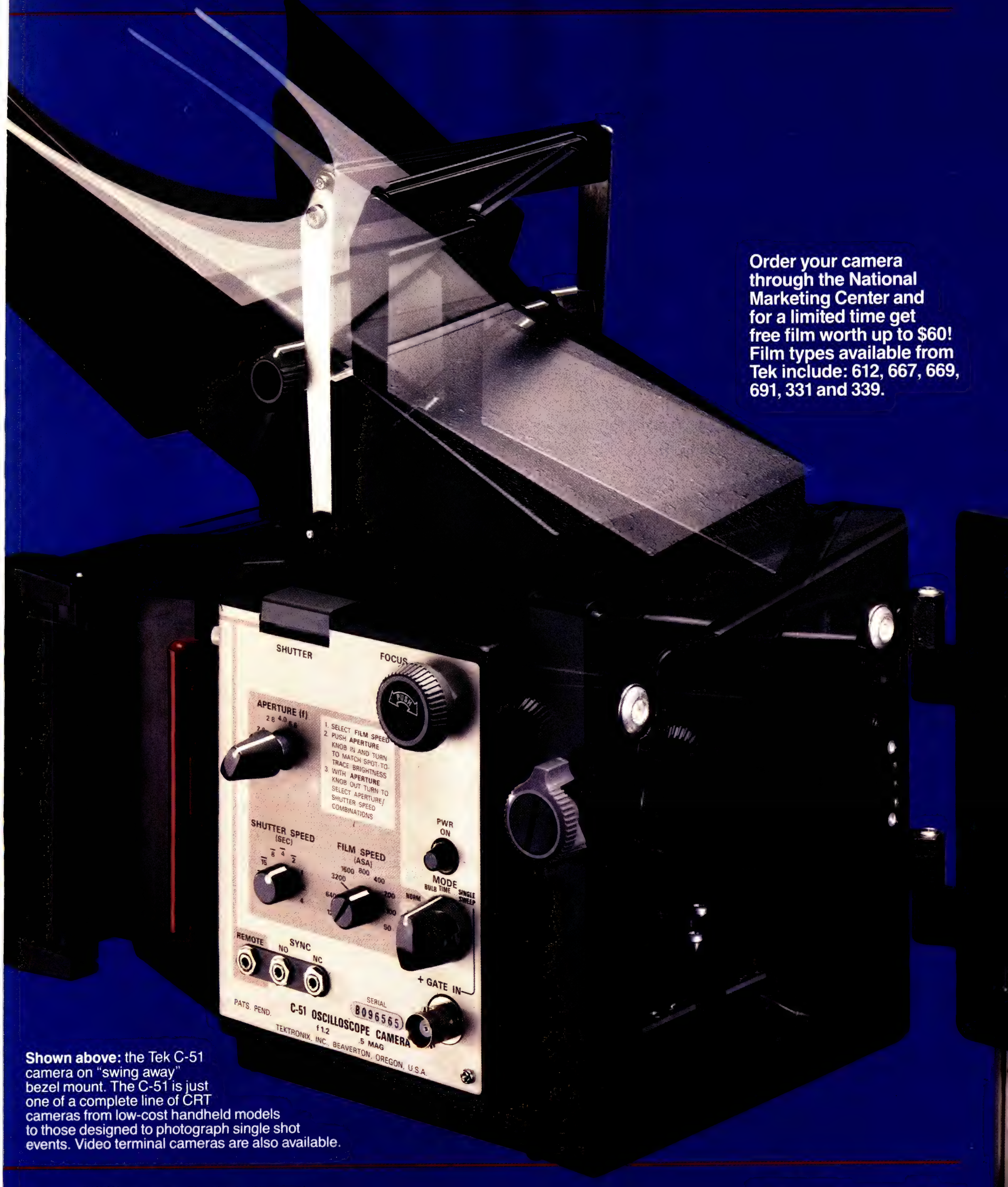

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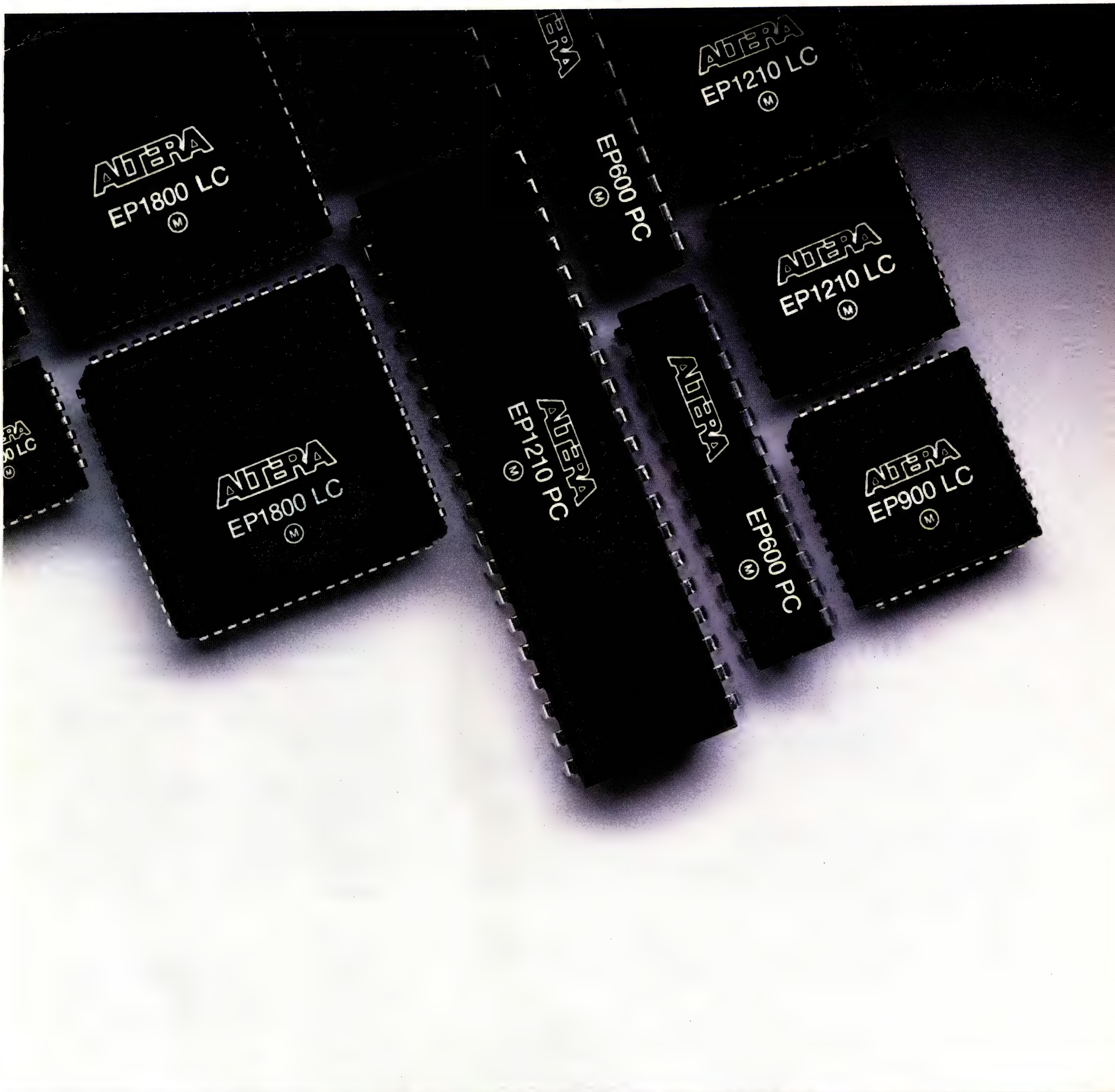

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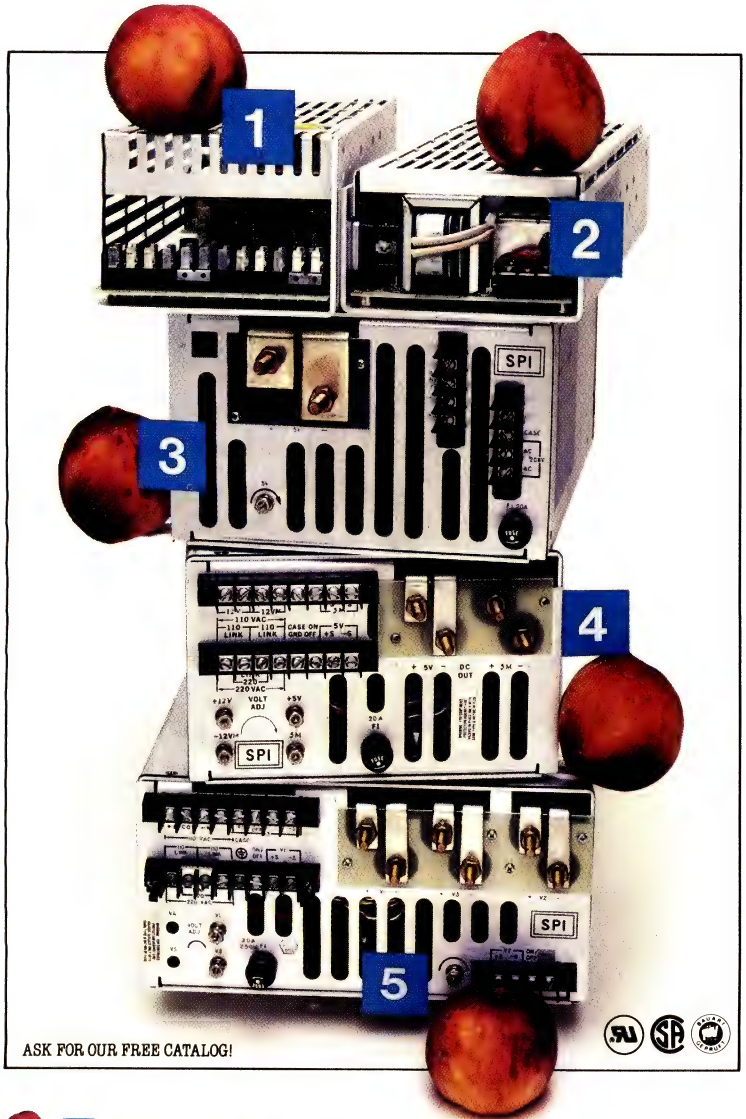

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CALENDAR

Alumni vs The State of the Art in the World of Substrates (seminar), DeKalb, IL. Northern Illinois University, (815) 753-1000. April 8.

Instrumentation '86, Portland, OR. Instrument Society of America/ Portland Section, Box 12152, Portland, OR 97212. (503) 297-1533. April 8 to 10.

15th Annual International Programmable Controllers Conference and Exposition, Detroit, MI. Engineering Society of Detroit, 100 Farnsworth Ave, Detroit, MI 48202. (313) 832-5400. April 8 to 10.

CommunicAsia '86 (Asian International Electronic Communication Show and Conference), World Trade Ctr, Singapore. Kallman Associates, 5 Maple Ct, Ridgewood, NJ 07450. (201) 652-7070. April 9 to 12.

World Market for Electronics and Electrical Engineering '86, Hannover, West Germany. Hannover Fairs USA Inc, Box 7066, Princeton, NJ 08540. (609) 987-1202. April 9 to 16.

Intermag '86 (International Magnetics Conference), Phoenix, AZ. J U Lemke, 2400 6th Ave, #1103, San Diego, CA 92101. (619) 755-1393. April 14 to 17.

Modern Power Conversion Design Techniques (short course), Ottawa, Ontario, Canada. E/J Bloom Associates, 115 Duran Dr, San Rafael, CA 94903. (415) 492-8443. April 14 to 18.

PL/M-86 Systems Programming (short course), Madison, WI. Micro-Managers Inc, 1435 E Main St, Madison, WI 53703. (608) 251-6661. April 14 to 18.

Computer Graphics '86, New York, NY. Andry Montgomery & Associates, 8300 Greensboro Dr, Suite 690, McLean, VA 22102. (703) 893-4545. April 15 to 17.

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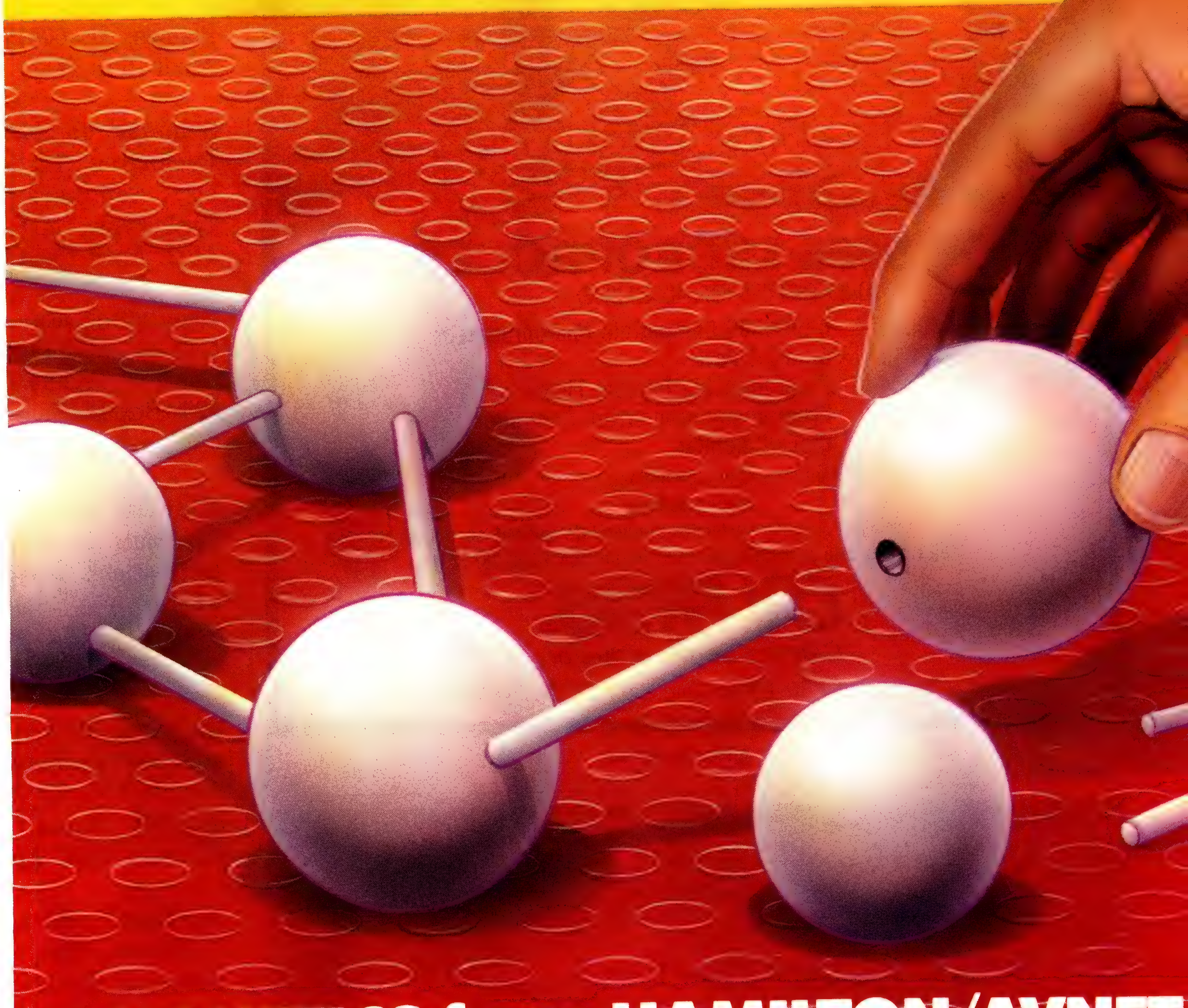

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CIRCLE NO 33

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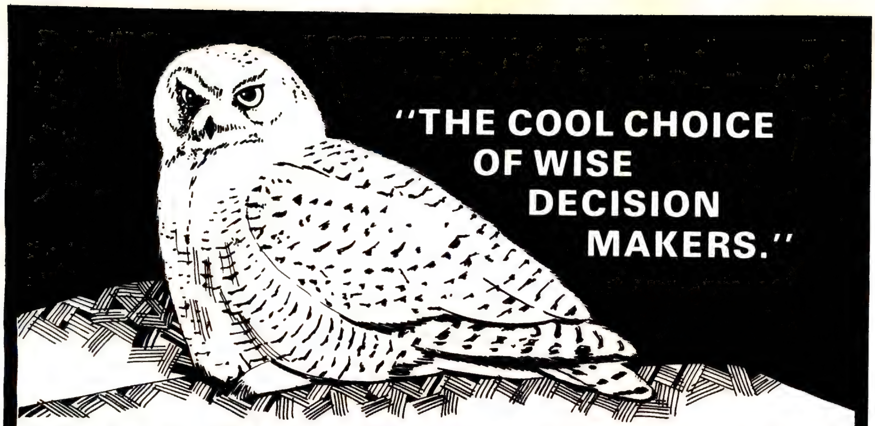

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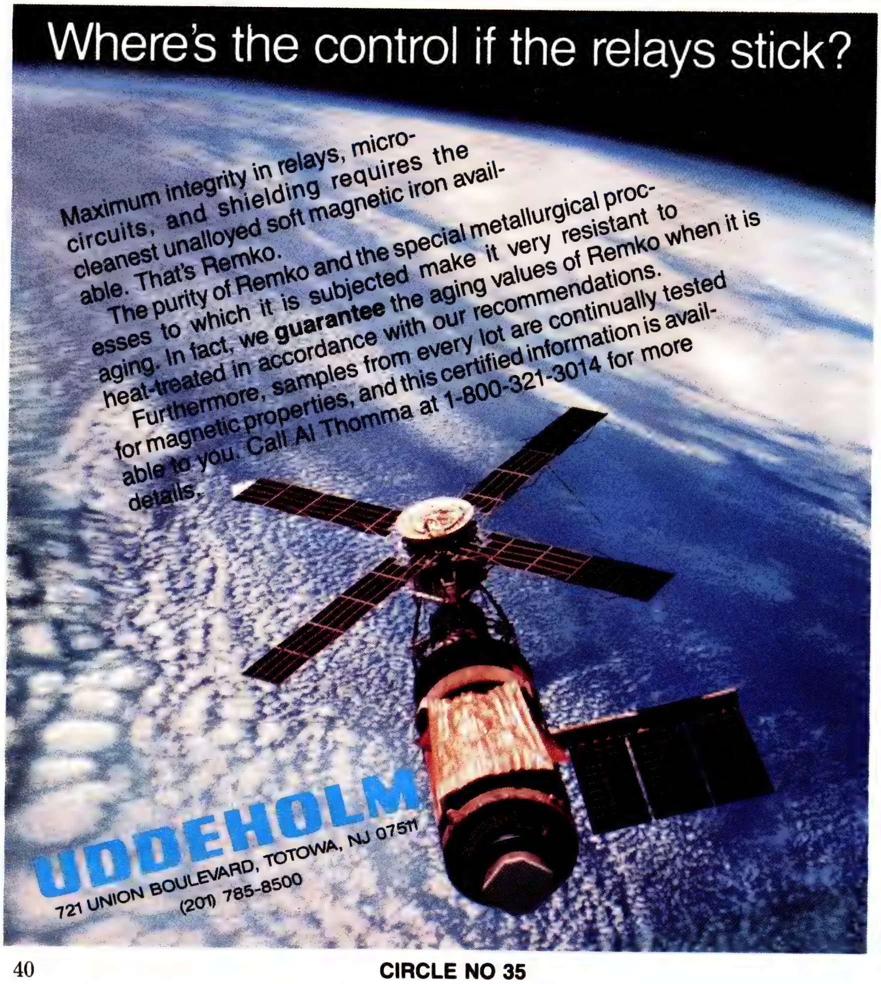

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CALENDAR

ElectroTest, Orlando, FL. Cahners Exposition Group, Box 5060, Des Plaines, IL 60017. (312) 299-9311. April 15 to 17.

Seminar on Modern Electronic Packaging, Anaheim, CA. Technology Seminars Inc, Box 487, Lutherville, MD 21093. (301) 269-4102. April 15 to 17.

Grounding and Shielding (short course), Atlanta, GA. Interference Control Technologies, State Rte 625, Box D, Gainesville, VA 22065. (703) 347-0030. April 15 to 18.

Midwest Electronics Exposition, St Paul, MN. Morgan-Grampian Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. April 16 to 17.

RF and Microwave Component and Test Equipment Exhibit, Fort Wayne, IN. RF Management Inc, Box 336, Beech Grove, IN 46107. (317) 887-1349. April 16 to 17.

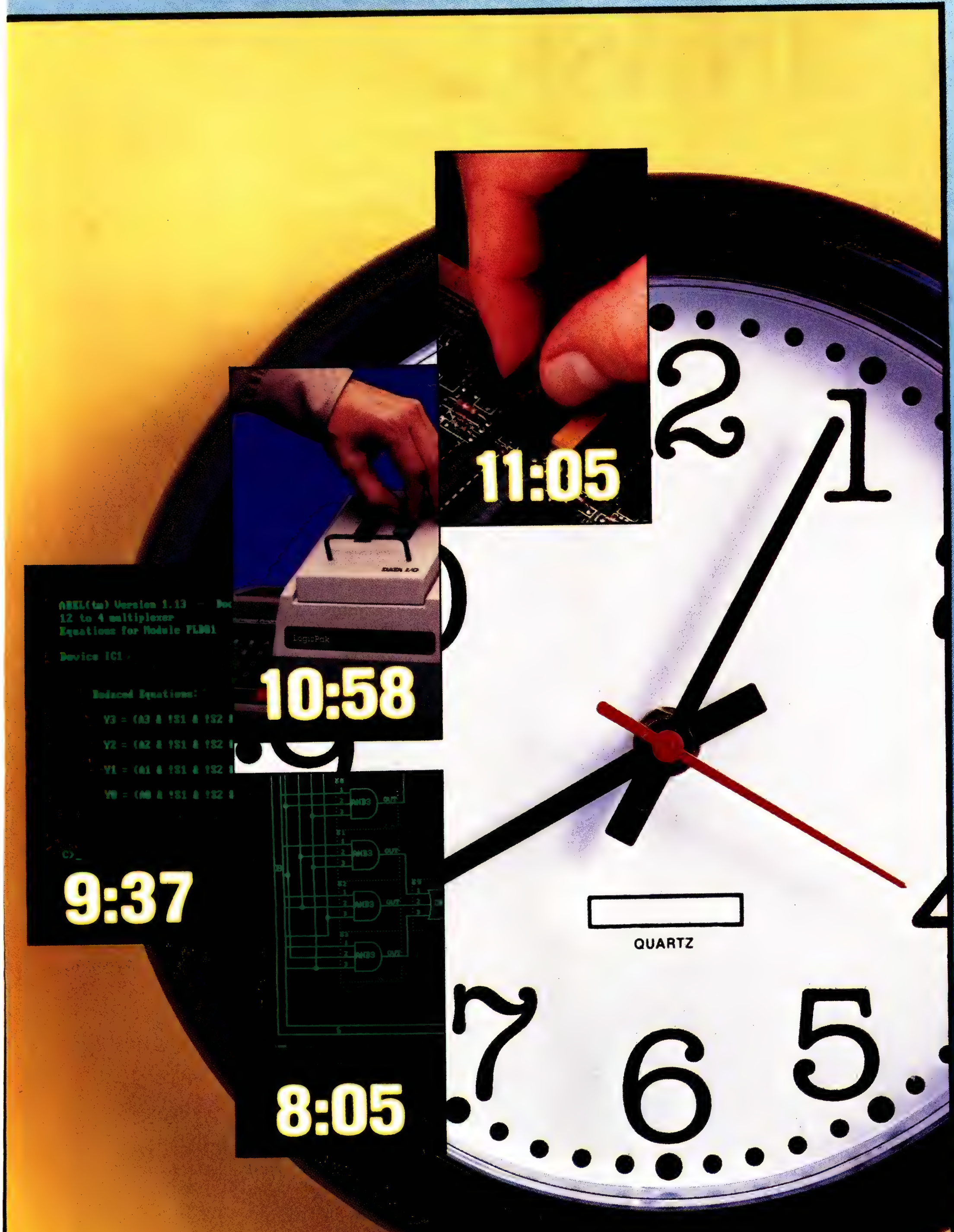
National Relay Conference, Stillwater, OK. Dan Lingelbach, School of Electrical and Computer Engineering, Oklahoma State University, Stillwater, OK 74078. (405) 624-5168. April 21 to 23.

Financial Information Systems—Integrating Personal Computers, Chicago, IL. National Institute for Management Research, Box 3727, Santa Monica, CA 90403. (213) 450-0500. April 21 to 23.

iRMX 86 for Users (short course), Madison, WI. Micro-Managers Inc, 1435 E Main St, Madison, WI 53703. (608) 251-6661. April 21 to 25.

EMC Design & Measurement for Control of EMI (short course), Philadelphia, PA. Interference Control Technologies Inc, State Rte 625, Box D, Gainesville, VA 22065. (703) 347-0030. April 21 to 25.

CONCEPT TO SILICON IN THREE HOURS? WE'LL SHOW YOU HOW!



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DATA I/O from HAMILTON/AVNET

THIS IS HOW BIG NCR HAS GROWN IN ASIC.

THE PRODUCTS

2 μm and 3 μm CMOS Gate Arrays
- Choice of six different arrays
- 650 to 5000 *usable* gates—today
- Extensive library of over 100 cell macros
- 40 to 120 input/output pads
- 1.1 ns typical 2 input NAND gate delays
- Toggle frequencies up to 85Mhz
- Clock frequencies up to 50Mhz

Standard Cell Libraries
- Extensive families of SSI, MSI and LSI cells
- Large family of high-performance function blocks such as core MPUs, Supercells and analog cells
- Up to 20,000 equivalent gates
- Over 150 input/output pads
- 1.1 ns typical 2 input NAND gate delays
- Toggle frequencies to 85Mhz
- Clock frequencies to 50Mhz
- Output drivers to 48mA

2 μm Standard Cells
- Advanced high performance features
- High density cells for best silicon usage
- High speed cells for optimum performance
- True system integration on a chip

3 μm Standard Cells
- Highly cost effective for moderate performance, cost-sensitive designs
- Over 250 designs completed

Analog Cell Library
- Allows mixing digital and analog on a chip
- Over 20 function blocks including op amps, comparators, analog switches, voltage references and oscillators
- Special function blocks such as flash A/D converters, sound generators, bias supplies and negative voltage generators

Supercells
- Modular EEPROM memories
- Configurable RAM and ROM
- PLA building blocks
- A/D and D/A converters
- Counter timers
- Advanced function blocks such as SCSI controllers and UARTS

Core MPU Cells
- Allows system integration on a chip
- 65C02 now
- 68C05 and 80C51 by late '86
- Others to follow

Several Library Options
- High quality commercial temperature range
- Extended temperature military library
- High temperature automotive library
- Special testing and screening available
- Wide selection of standard and optional packaging

THE DESIGN TOOLS

Common CAD System
- All NCR ASIC products supported on an integrated CAD system
- Eliminates learning multiple systems for gate arrays and standard cells
- CAD systems will grow with advances in technology

Workstation Support
- Leading industry standard workstations, such as Mentor Graphics, Daisy and Valid are fully supported
- Complete workstation CAD tools available from schematic capture to test program generation
- Features both pre and post layout simulators and place/route capability

Migration Path
- Allows migration from 3 μm to 2 μm and beyond
- Provides for migration between gate arrays, standard cells and soon, Silicon Compilers
- Eliminates ASIC design obsolescence when system performance must be improved

Integrated CAD Tools
- NCR CAD tools are fully integrated into a single easy to use package
- System interfaces with many popular off-the-shelf tools
- Users have common system interface regardless of design option

Complete User Support
- Comprehensive documentation
- In-depth customer training
- On-line phone support
- Timely system updates

Advanced Timing Analysis Package
- Features NCR proprietary tools such as VITA,® SENTPEX,® COMPOSE and STARS
- Insures designs work first time out
- Provides worst case/best case analysis
- Outputs typical case timing delays for performance specification generation

Flexible Test Program Generation
- System creates full functional test patterns
- User definable speed path test generation

THE SUPPORT

Military Products Group
- Dedicated to Military designs
- On-site internal fab, and testing facilities
- Screening to 883C Method 5010 on a stand-alone basis
- Able to support developmental and small lot designs
- Dedicated Mil design center

Automotive Products Group
- On-site internal circuit design, fab and testing facilities
- Extended temperature ranges
- Special reliability testing and screening
- Cell customization available
- Dedicated design center

Commercial Products Group
- Dedicated to commercial ASIC designs
- On-site internal circuit design, fab, assembly and testing
- Headquarters for ASIC R&D design group
- CAD tool development group
- Extensive customer support capabilities

Independent Design Centers
12 Locations
- Aptek Microsystems, Inc.
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THIS IS HOW SMALL.

Typical size
2 μm die.

What's the best measure of an ASIC supplier?

NCR thinks you have to look at it from both sides. Just how big is your supplier. And how small.

NCR's library speaks volumes.

Cell libraries are where bigger usually means better. NCR's comprehensive library of 3 μm CMOS cells has made it the leading merchant producer of standard cells today.

And our 2 μm double-level-metal cell library has almost twice as many cells.

Both libraries are rich in capabilities. NCR's analog cell library is unmatched in the industry. And there is a versatile selection of core microprocessors, configurable EEPROM, RAM and ROM memories, plus cells for on-chip programmable logic arrays.

The small advantage.

NCR's 2 μm N-well double-level-metal technology offers designers the sizeable advantage of smaller geometries. Generally, 2 μm DLM CMOS increases performance two-fold—with unrestricted clock rates up to 30mHz and restricted clock rates to 50mHz. All that with a 50 percent reduction in die size over 3 μm designs.

The migratory pattern of engineerus electronicus.

History has proven that design engineers move as quickly as the market demands and technology allows. That's why NCR has provided a migratory path from 3 μm SLM to 2 μm DLM without time consuming or costly redesigning.

The Alliance: One more big reason.

NCR's recent alliance with Motorola has created a huge capability for today's engineers. NCR now offers a complete line of 3 μm and 2 μm gate arrays as well as its industry leading line of standard cells. And both libraries are integrated on industry-standard workstations such as Daisy,® Mentor Graphics® and Valid.® So in addition to the 3 μm to 2 μm migration, NCR offers migration from gate arrays to standard cells.

Your decision.

In the final analysis, it's not really who's big and who's little, but who's best. Isn't it interesting that that's NCR too.

For more information, call 303-226-9500 for the name of your nearest NCR sales representative, or call any of the design centers listed on the left.

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CIRCLE NO 37

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CIRCLE NO 38

EDITORIAL

Don't legislate radio security

Many people who use cellular phones, cordless phones, and other 2-way radio communications don't realize their conversations are not private. Such conversations are easy to monitor with a shortwave receiver or scanner. In fact, the Communication Act of 1934 affirms your right to receive any or all radio transmissions. To help ensure private communications, several legislators think government should protect certain 2-way radio transmissions from interception and use.

Instead of urging Congress to pass another set of feckless laws, the communication industry should use available technology to solve its communication-security problem. For example, by using a simple technique such as frequency inversion, many police and fire departments can adequately scramble their communications. And although an eavesdropper may soon be able to obtain a descrambler, it's not difficult to use new technology to keep secure communications a step ahead.

Consider also HBO's approach. Instead of asking for laws that would ban satellite-TV receivers, HBO recently started encoding its TV broadcasts so they're difficult if not impossible for satellite-dish owners to use. To continue watching HBO's movies you must buy their special decoder. HBO has the right to scramble its signals, but you still have the right to receive them. By applying today's µPs, digital-signal-processing chips, data-encryption standard chips, and other encoding devices, the telecommunications industry can offer its customers almost absolute security.

Unfortunately, many segments of the telecommunications industry support the Electronic Communications Privacy Bill of 1985 (S 1667 and HR 3378), which is now before Congress. By making it illegal to intercept transmissions that aren't "readily accessible to the public," the bill attempts to put cellular-phone, paging, videoconference, and other transmissions off limits to casual listeners.

However, the bill will be almost impossible to enforce because it doesn't outlaw radio receivers or limit a receiver's coverage. It's difficult to imagine the Federal Communications Commission tracking down people who eavesdrop on 2-way radio transmissions. In short, the Privacy Bill is buck passing. Because current technology has many sophisticated data-security solutions already on the shelf, it's disappointing to see so many people in the telecommunications industry embrace an unenforceable government solution.

Jon Titus

Jon Titus
Senior Editor

DIGITAL SIGNAL PROCESSING:

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7281	Image Pipelined Processor	Image processing and general-purpose DSP	True parallel processing, non-von Neumann architecture
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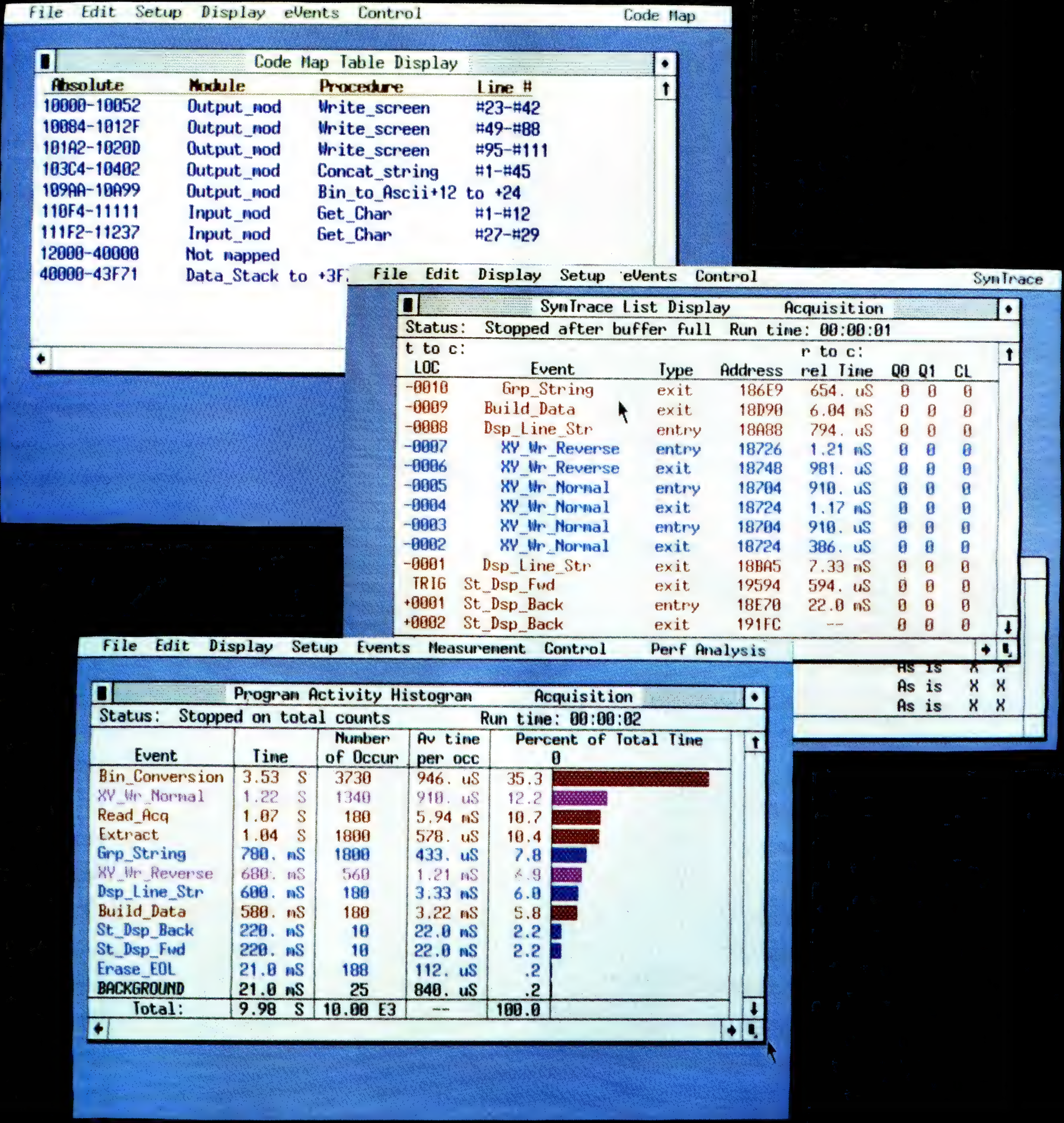
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Code Map
Code Map Table Display
File Edit Display Setup eVents Control
SymTrace
SymTrace List Display Acquisition
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Program Activity Histogram Acquisition

```
Absolute      Module       Procedure        Line #
10000-10052   Output_mod   Write_screen     #23-#42
10084-1012F   Output_mod   Write_screen     #49-#88
101A2-1020D   Output_mod   Write_screen     #95-#111
103C4-10402   Output_mod   Concat_string    #1-#45
109AA-10A99   Output_mod   Bin_to_Ascii+12 to +24
110F4-11111   Input_mod    Get_Char         #1-#12
111F2-11237   Input_mod    Get_Char         #27-#29
12000-40000   Not mapped
40000-43F71   Data_Stack to +3F
```

```
Status:  Stopped after buffer full  Run time: 00:00:01
t to c:                                    r to c:
 LOC          Event         Type   Address  rel Time   Q0 Q1  CL
-0010          Grp_String    exit    186E9   654. uS    0  0   0
-0009        Build_Data      exit    18D90   6.04 mS    0  0   0
-0008        Dsp_Line_Str    entry   18A88   794. uS    0  0   0
-0007          XY_Wr_Reverse entry   18726   1.21 mS    0  0   0
-0006          XY_Wr_Reverse exit    18748   981. uS    0  0   0
-0005          XY_Wr_Normal  entry   18704   910. uS    0  0   0
-0004          XY_Wr_Normal  exit    18724   1.17 mS    0  0   0
-0003          XY_Wr_Normal  entry   18704   910. uS    0  0   0
-0002          XY_Wr_Normal  exit    18724   386. uS    0  0   0
-0001        Dsp_Line_Str    exit    18BA5   7.33 mS    0  0   0
 TRIG      St_Dsp_Fwd        exit    19594   594. uS    0  0   0
+0001      St_Dsp_Back       entry   18E70   22.0 mS    0  0   0
+0002      St_Dsp_Back       exit    191FC    --        0  0   0
```

```
As is   X  X
As is   X  X
```

```
Status:  Stopped on total counts          Run time: 00:00:02
                                Number      Av time    Percent of Total Time
     Event          Time        of Occur    per occ          0
Bin_Conversion    3.53   S      3730       946. uS     35.3
XY_Wr_Normal      1.22   S      1340       910. uS     12.2
Read_Acq          1.07   S       180       5.94 mS     10.7
Extract           1.04   S      1800       578. uS     10.4
Grp_String        780.  mS      1800       433. uS      7.8
XY_Wr_Reverse     680.  mS       560       1.21 mS      6.9
Dsp_Line_Str      600.  mS       180       3.33 mS      6.0
Build_Data        580.  mS       180       3.22 mS      5.8
St_Dsp_Back       220.  mS        10       22.0 mS      2.2
St_Dsp_Fwd        220.  mS        10       22.0 mS      2.2
Erase_EOL         21.0  mS       188       112. uS       .2
BACKGROUND        21.0  mS        25       840. uS       .2
   Total:         9.98   S    10.00 E3       --       100.0
```

INTRODUCING THE SOFTANALYST™ FROM NORTHWEST INSTRUMENT SYSTEMS.

The dark side.

When you finally execute your code on a target microcomputer system, you're often left completely in the dark.

Which procedure is calling which? Which modules are consuming the most CPU time? Is the stack overflowing? Are interrupts serviced fast enough? Is all the code being tested?

The bright side.

A new class of measurement tool, the SoftAnalyst from Northwest Instrument Systems, gives you the first complete solution to real-time analysis of high-level programs. It's a non-intrusive, non-statistical system that works with high level languages (e.g. C, Pascal, PL/M and FORTRAN) and assembly.

High-level trace of program and data flow.

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The SoftAnalyst is compatible with a wide spectrum of languages and development environments. It supports multiple microprocessors. So you can use it now and in the future, as your design environment changes.

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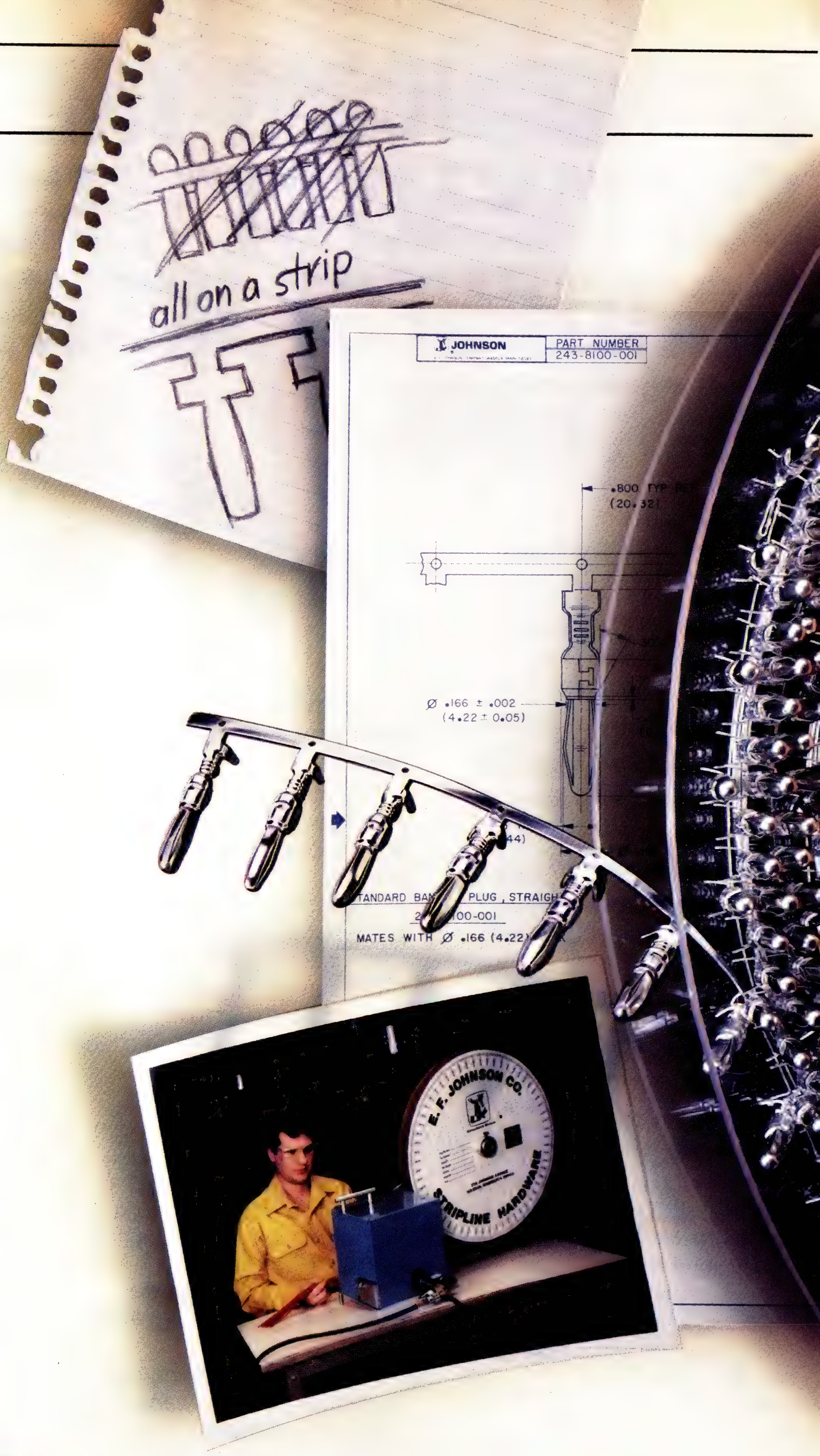

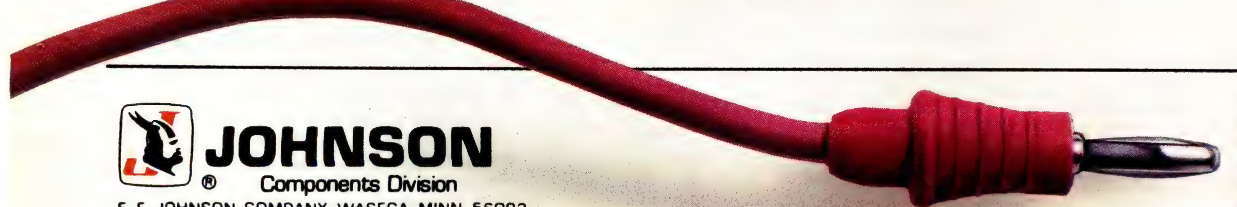

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TECHNOLOGY UPDATE

Increasing popularity of MAP spurs market for compatible chips, boards, and boxes

Steven H Leibson,
Southwestern Editor

The drive towards computer-integrated manufacturing and factory automation by corporate giants like General Motors and Ford is forcing industrial LAN technology to standardize in the direction of the manufacturing automation protocol (MAP). Factory planners are attracted to the MAP's promise of plant-wide sharing of information among all sectors of an organization, from work cells to order-processing, inventory-management, and engineering departments, on up to the executive suite. MAP compatibility ensures that devices from various manufacturers will be able to communicate over a common network, overcoming the problem of coordinating small, scattered groups of incompatible equipment, which GM calls "islands of automation."

The MAP standardization effort has gained so much momentum that vendors of computers, robots, and programmable controllers may soon be required, by virtue of the demand, to incorporate MAP compatibility in their equipment. Sensing a large potential market, several vendors have recently introduced products that make it easier than ever for you to design MAP compatibility into your system at the box, board, or chip level.

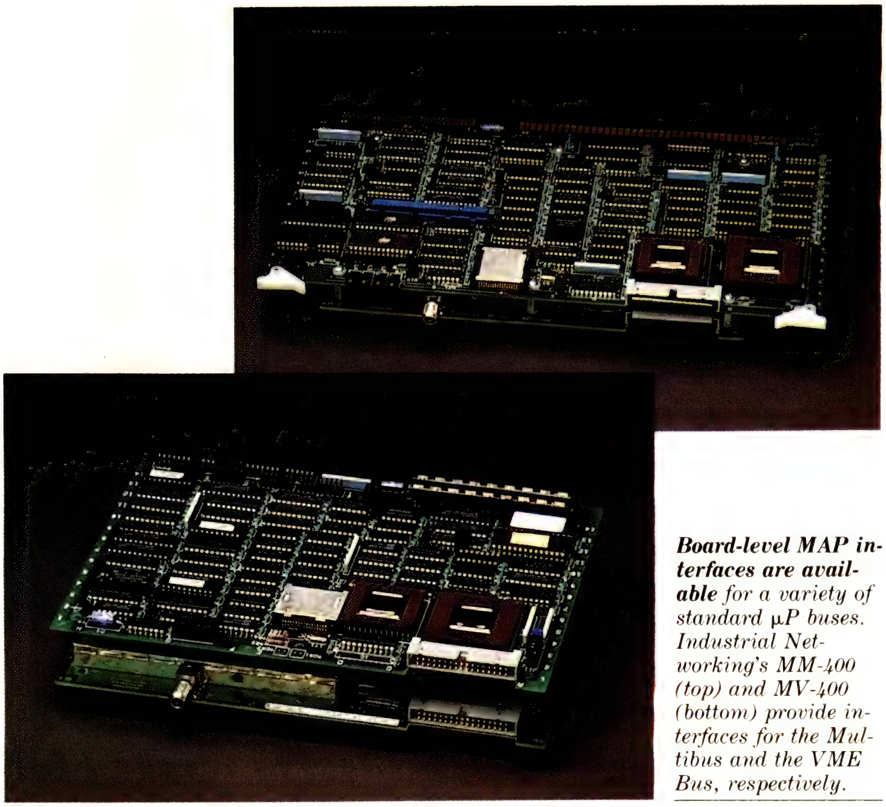
Layered communications

General Motors created the MAP, which is based on the International Standards Organization's 7-layer Open Systems Interconnection (OSI) model for network communications. Several layers are based on existing IEEE, EIA, ANSI, or CCITT standards (**Table 1**). Where such standards do not yet exist, efforts are underway to establish them.

The MAP 2.1 specification defines layer 1, called the physical layer, as a 10M-bps, broadband-RF connection conforming to the IEEE 802.4 specification (MAP 2.0 specified a 5M-bps connection). The network backbone is constructed with standard CATV components: semirigid, 75Ω, ½-in. coaxial cable; active RF amplifiers; and 2-, 4-, or 8-port passive taps. As much as 150 ft of RG-6 coaxial drop cable connects a device (an end system, in MAP terminology) to a tap.

Communication within a MAP network is unidirectional. A transmission from an end system must pass up the cable through the directional tap to a head-end remodulator, which decodes the data packets and retransmits the information down the cable at a different frequency to all of the end systems (**Fig 1** pg 54). The end system addressed picks the message up, while the others discard it. MAP 2.1 defines three transmit/receive RF pairs, allowing three independent MAP networks to coexist on a single physical link. The transmit frequency band is 59.75 to 95.75 MHz; the receive frequency band, 252 to 288 MHz. If you carefully allocate frequencies, the same coaxial backbone can carry video and audio information as well as non-MAP data.

Media-access-control (MAC) and logical-link-control (LLC) sublayers constitute layer 2, the data-link layer. MAP 2.1's MAC sublayer is the token-passing-bus portion of the



Board-level MAP interfaces are available *for a variety of standard μP buses. Industrial Networking's MM-400 (top) and MV-400 (bottom) provide interfaces for the Multibus and the VME Bus, respectively.*

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IEEE 802.4 spec. The LLC sublayer is defined as IEEE 802.2 class 1 service, which is a peer-to-peer, connectionless protocol ("connectionless" refers to message transmission that does not first require the sender to notify the receiver that a message is on the way). The transition from software or firmware to hardware in a MAP network node often is located at the MAC-LLC interface.

Layer 3, the network layer, is defined by MAP 2.1 as the ISO 8473 connectionless internet protocol, which means that the end system does not explicitly establish connections with other networks before transmitting messages. This layer establishes, maintains, and terminates network connections for end systems that link with multiple networks; routes data packets onto the network and between linked networks; and controls the flow and priority sequencing of messages.

Layer 4, the transport layer, separates data into packets at the sending system and reassembles the packets at the receiving end. This layer also provides data-packet error detection and recovery, monitors communications quality, and maps user-application names to network addresses. MAP 2.1 specifies the ISO 8073 class IV transport for layer 4. Class IV is the largest, most complex transport service.

Layer 5 is the session layer, which establishes a dialogue between two user applications running in different end systems. It also multiplexes layer-4 service among several user programs in a multitasking environment, ie, it allows a multitasking computer to send messages generated by the programs it's running out to the network. MAP 2.1 requires at least the kernel functions defined in ISO 8326/8327 in full-duplex mode.

Data translation and formatting are supplied by layer 6, the presentation layer. MAP 2.1 defines the function of this layer as null; the network does no translating or formatting at this level. Consequently, all applications must use the same data format. GM plans to add layer 6 at a later date. Layer 6 could be used for text compression, data encryption, or file-format conversion.

TABLE 1—MAP STANDARDS AND SPECIFICATIONS

STRUCTURE	STANDARD OR SPECIFICATION
OSI REFERENCE MODEL (OVERALL NETWORK STRUCTURE)	ISO 7498, X.200
APPLICATION LAYER (LAYER 7)	
SYSTEM MANAGEMENT/DIRECTORY SERVICES	ISO 8650/2-3, IEEE 802.1
MMFS	EIA 1393A/3
FTAM	DP 8571
CASE	DP 8649/1-3, 8650/1-3
PRESENTATION LAYER (LAYER 6)	CURRENTLY NULL
SESSION LAYER (LAYER 5)	DIS 8326, 8327, X.215, X.225
TRANSPORT LAYER (LAYER 4)	DIS 8072, 8073, 8602, X.214, X.224
NETWORK LAYER (LAYER 3)	DIS 8348, 8473, 8648, X.213, X.1 THROUGH X.29
DATA-LINK LAYER (LAYER 2)	
MEDIA-ACCESS-CONTROL SUBLAYER	IEEE 802.4
LOGICAL-LINK-CONTROL SUBLAYER	IEEE 802.2
PHYSICAL LAYER (LAYER 1)	DIS 802.4, X.211, IEEE 802.4

KEY:

DIS	DRAFT INFORMATION STANDARD (ISO)
EIA	ELECTRICAL INDUSTRY ASSOCIATION
DP	DRAFT PROPOSAL (ISO)
IEEE	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
ISO	INTERNATIONAL STANDARDS ORGANIZATION
X	CCITT (INTERNATIONAL TELEPHONE AND TELEGRAPH CONSULTATIVE COMMITTEE) PROTOCOL IDENTIFIER

SOURCE: *NETWORK CONCEPTS,* P/N 97-31173-02, NOVEMBER 1985, CHARLES RIVER DATA SYSTEMS, 983 CONCORD ST, FRAMINGHAM, MA 01701.

Awaiting definition

Layer 7 is the application layer, supplying network services to your application program. This layer is undergoing the most change. Services in layer 7 include file transfer, access, and management (FTAM), which is MAP's file system; common application service elements (CASE), which allow the application program to create an association with a remote peer application over the network; and manufacturing message format standard (MMFS, pronounced Memphis), which establishes a common structure and syntax for messages between peer applications.

MMFS is evolving under EIA working group 1393A/3 and will eventually become the RS-511 standard. GM developed MMFS as a control language for numerical-control machines; the 1393A/3 proposal adds commands for programmable controllers, robots, and other devices on the factory floor. A major difference between MMFS and RS-511 is the command syntax. RS-511 will use the metalanguage notation of the CCITT X.409 and ISO ASN.1 standards.

Your application program, which performs the non-network tasks in your end system, uses the services available from layer 7 to access the MAP network. Not all software products implement all layer-7 services completely. You need to decide what layer-7 services your application requires before choosing a vendor.

Boeing Computer Services is championing a network called the Technical Office Protocol (TOP), similar to MAP at layer 3 and above, but using the IEEE 802.3 Ethernet spec instead of the token bus for layers 1 and 2. A network bridge consisting of separate MAP and TOP physical and data-link layers, connected by a common layer 3, allows MAP and TOP networks to exchange data. Layers 4 and above are not needed by the network bridge. Designers envision TOP as an office network that could be linked to a manufacturing department's MAP network, and MAP users should note that a significant portion of MAP definition activity is devoted to MAP-TOP compatibility.

Twenty-one companies participated in a simulation of the MAP 2.1 factory-automation system at the Autofact show in Detroit last November. The demonstration linked MAP and TOP networks, simulating a manufacturing floor and management information system. End systems were programmable controllers, robots, and computers. As a demonstration of overall system flexibility, show attendees directed these end systems to produce towers-of-Hanoi puzzles, custom built from base, pegs, and rings in a choice of red, white, or blue colors for each component.

Orders logged into the system through the TOP network were manufactured and inspected by machines on the MAP side. Based on the problems encountered during the Autofact system integration, GM is planning to issue a new version of the specification, called "MAP 2.1 with errata." The new version will be available by the end of this month, and it will remove the discovered inconsistencies in MAP 2.1. If the MAP products you're considering meet the 2.1 standard, you should remember to ask whether the product has taken the improvements into consideration.

Version 2.2 of MAP is due in June or July. It will clarify CASE services, define broadband frequency allocation and network media sharing, and increase the number of functions available in directory services. An appendix will include an enhanced performance architecture (EPA) overview, which defines an interface between the application and the data-link layer. This interface will allow time-critical tasks to bypass several MAP layers. The facility is a response to system integrators' concern about the real-time abilities of MAP networks. Currently, data packets must traverse all seven network layers twice in moving from one end-system application to another.

MAP 2.2 will also include a carrier-band alternative for layer 1, to be used primarily in such MAP subnetworks as manufacturing cells. Although broadband transmission is preferred for very large networks, broadband modems are expensive and are not readily integrated in silicon. Carrier-band modems operate at much lower frequencies (5 to 10 MHz) than broadband-RF modems, so the required circuitry is simpler. The IEEE 802.4B committee is working on a carrier-band proposal.

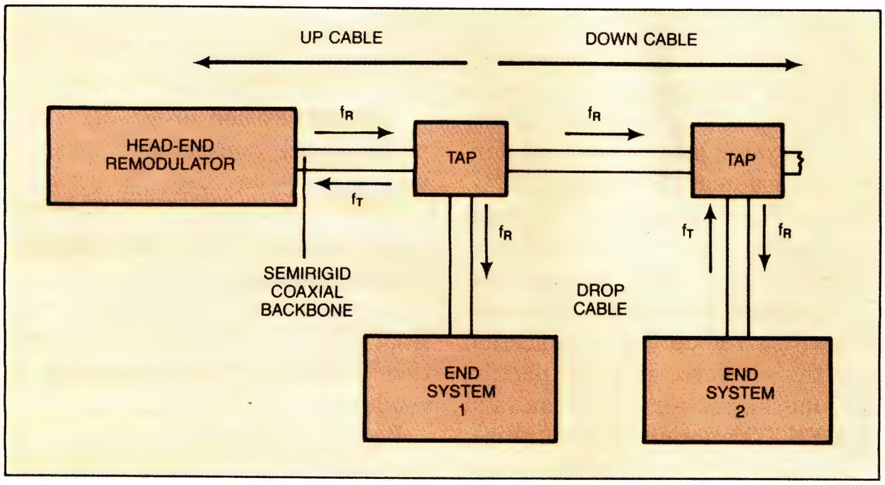

Fig 1—End systems in MAP networks use two frequencies to communicate. *In this example, end system 2 transmits a data packet to end system 1 by modulating a transmit carrier frequency (f_T). The transmission travels up the drop cable to the directional tap, which routes the signal to the head-end remodulator. After decoding the transmission, the head-end remodulator sends the data packet down the cable on receive frequency f_R to all end systems, including end system 1.*

MAP 3.0 is due late this year or early in 1987. It will add more specifications and options for use of the FTAM and CASE services. Also to be added is information on network routing and topology maintenance. The definition of the network manager will specify more functions than the MAP 2.1 definition specifies, and RS-511 will replace MMFS according to EIA 1393A/3 recommendations.

Real products are available

Although the MAP specification is still evolving, vendors are not waiting to offer products compatible with a final version. You can add MAP networking capability to your designs in the form of chips, standalone box-level products, or boards. Some products are available now, and others will appear throughout the remainder of the year.

Motorola offers the $75.94 (100) 68824 token-bus-controller IC, which implements the MAC sublayer of the MAP's data-link layer. The 68824 includes an onboard DMA controller with 32-bit addressing capability, an 8- or 16-bit data-bus interface, and byte-swapping to support 16-bit, non-Motorola host μPs. The 68824 directly connects to a MAP broadband or carrier-band modem over an IEEE 802.4G-compatible interface.

This month, Motorola will start sampling the 68184, which implements the digital portion of a MAP broadband-RF modem. The 68184 operates at data rates to 10M bps, and the company estimates the part will cost approximately $15 (100)

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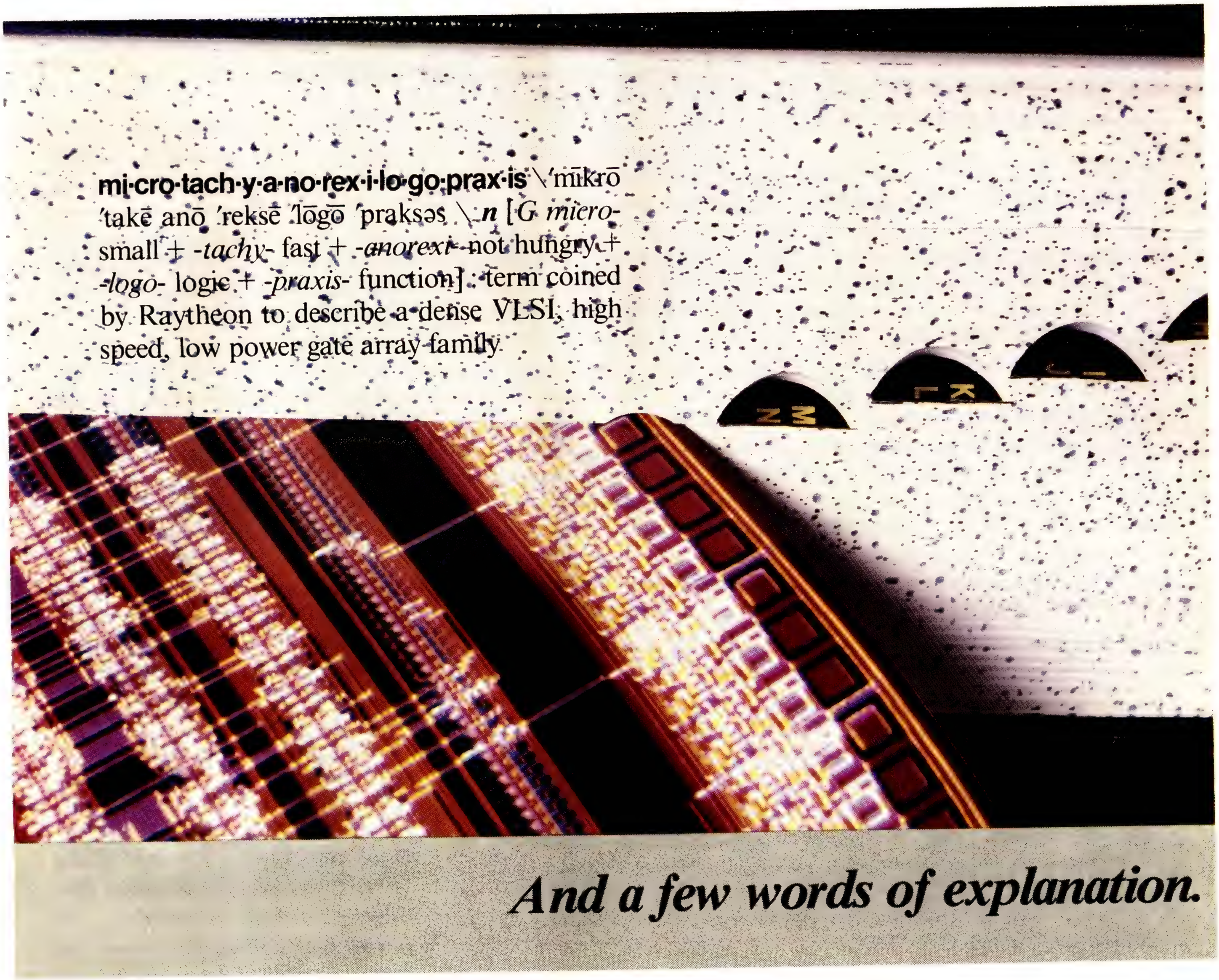

mi·cro·tach·y·a·no·rex·i·lo·go·prax·is \ˈmīkrō ˈtakē anō ˈreksē ˈlōgō ˈpraksəs \ *n* [*G micro-* small + *-tachy-* fast + *-anorexi-* not hungry + *-logo-* logic + *-praxis-* function] : term coined by Raytheon to describe a dense VLSI, high speed, low power gate array family

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when in full production in 1987.

Motorola plans to furnish samples of the 68194 chip in September or October. The 68194 incorporates a carrier-band modem and will transmit at 1M, 5M, and 10M bps. It's designed to interface directly with the network's coaxial cable and is projected to cost $25 (100) next year. Both the 68184 and 68194 support the IEEE 802.4G modem interface.

Stand-alone products constitute the easiest of the three paths to MAP compatibility. They typically provide access to the MAP network from an RS-232C or an RS-449/422 port. Often called network-interface units (NIUs) or bus-interface units (BIUs), these stand-alone products were the first to offer a packaged solution to MAP interfacing.

Concord Data Systems offers several stand-alone MAP-interface products, called Token/Net interface modules (TIMs). "Token/Net" is the name Concord gives its version of the MAP token-bus network. TIMs are available with 5M-bps carrier-band and 5M- and 10M-bps broadband network interfaces.

The Terminal Server TIM supports four to 12 RS-232C or RS-422 ports at data rates of 75 to 19.2k bps (asynchronous) and 1200 to 19.2k bps (synchronous). Prices range from $3225 to $4740, depending on network speed, modulation type (carrier-band or broadband), and expansion options. The Terminal Server TIM implements layers 1 through 4 of the MAP, topped by a proprietary, serial-port application layer developed by Concord to interface terminals and other serial devices to MAP networks.

For end systems that handle the upper layers of the MAP, Concord offers the Mapserver and Mapserver/Plus TIMs. You can choose either a layer-2 or a layer-5 interface to the Mapserver TIMs, and you have the same network-speed and modulation options. The Mapserver supports two RS-449/422 ports with data rates of 9600 to 230k bps (layer-2 interface) and 9600 to 56k bps (layer-5 interface). The Mapserver/Plus is expandable, supporting four to 12 RS-232C or RS-449/422 ports at data rates from 75 to 19.2k bps (RS-232C) and 9600 to 64k bps (RS-449/422). Prices of the Mapserver and the 4-port Mapserver/Plus range from $4335 to $6200 and from $4500 to $5845, respectively.

Putting MAP on your bus

For products that use a standard microprocessor bus, you can probably find a MAP-network-interface board set that fits in your card cage. Board-level products come complete with software implementation up through layer 7.

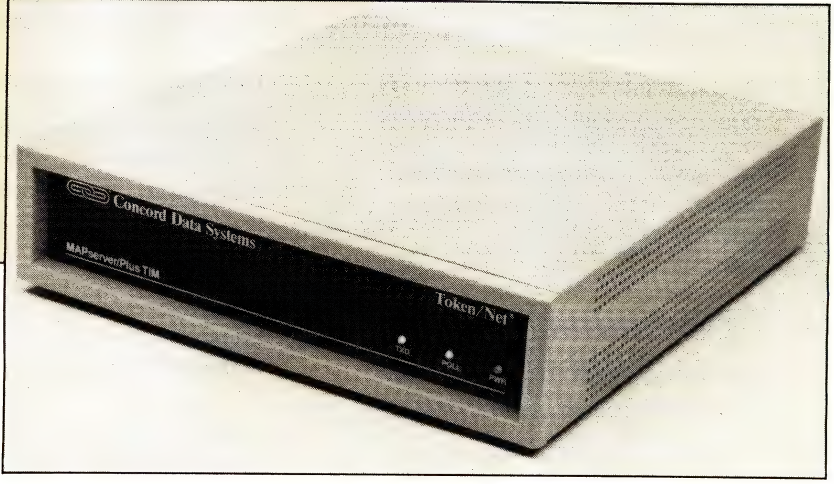
Industrial Networks Inc offers a wide variety of board-level, MAP-compatible interfaces. The MM-400, MP-400, and MV-400 board sets plug into the Multibus, PC Bus, and VME Bus, respectively. Each includes a MAP controller and a 10M-bps broadband-RF modem. A general-purpose MG-400 board set supports a serial RS-422 host interface. All INI board sets cost $3500 and implement the full seven layers of the MAP. Software executes on a resident 80186 processor.

Motorola plans to start shipping the MVME372 advanced MAP-network interface controller for the VME Bus in July. The manufacturer is currently testing the board for MAP compliance. The MVME372 incorporates the 68824 token-bus controller, which implements the

A users' group for MAP

The MAP Users' Group is part of the Society of Manufacturing Engineers and is a focal point for the evolving MAP specification and related product development. The group has held quarterly conferences since September of 1984. These sessions include tutorial programs, progress reports on standardization efforts, and announcements of new products. About 500 people attended the last conference, held in Toronto last January. The next meeting will take place in Seattle on May 14 and 15, 1986. For more information, contact

Mark Shaw
MAP Users' Group
Society of Manufacturing Engineers
Box 930
Dearborn, MI 48121
(313) 271-1500.



The simplest approach to MAP interfacing *is through a box-level product like the Mapserver/Plus from Concord Data Systems, which can connect four to 12 RS-232C or RS-449/422 devices to a MAP network.*

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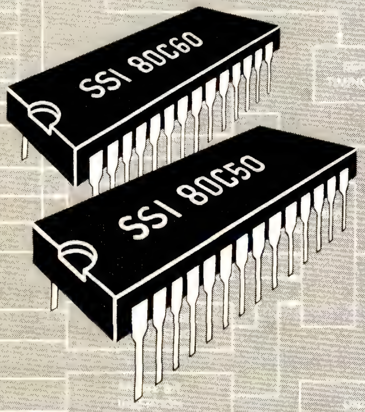

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MAC sublayer, and a 68020 μP that runs Micromap software for the upper layers of the protocol. Pricing of the board will be less than $3000. An object license for the Micromap software will cost $600.

Intel's iSXM 554 MAP communications board for the Multibus costs $3750, comes with a companion RF-modem board, and includes a configured version of the company's iNA 960 software, which implements MAP 2.1 from the LCC sublayer through layer 4. An 8-user development license for MAP-Net software, which adds layers 5 to 7, costs $2000. Pricing for a MAP-Net object license has not yet been determined.

Concord Data Systems plans to ship its Mapware interface board for the Multibus in June. Based on a proprietary chip implementing the IEEE 802.4 protocol, the controller board includes software for layers 3 to 7. You can order a board bundled with a 5M- or 10M-bps carrier-band modem ($2850), bundled with a 10M-bps broadband modem ($3500), or unbundled ($2500). Concord Data is planning to offer similar interface boards for other buses and is working with Digital Equipment Corp on a MAP interface for MicroVAX computers using the Q Bus.

When unbundled MAP controller boards like Motorola's MVME372 and Concord Data Systems' Mapware Series become available, you will be able to select a MAP RF-modem board from a vendor other than your controller-board vendor. Two companies offering board-level RF modems are Fairchild Data and Scientific-Atlanta. Fairchild Data's M8024 MAP-link modem currently serves VME Bus and Multibus systems and costs less than $500 (2000 quantity over two years). The company will introduce Q Bus and Unibus versions of the M8024 in May, at prices less than $1000 (200). Scientific-Atlanta plans to offer its Model 6420 modem in the third quarter of this year. The board is currently undergoing interoperability testing with Motorola's MVME372. It will cost $799. **EDN**

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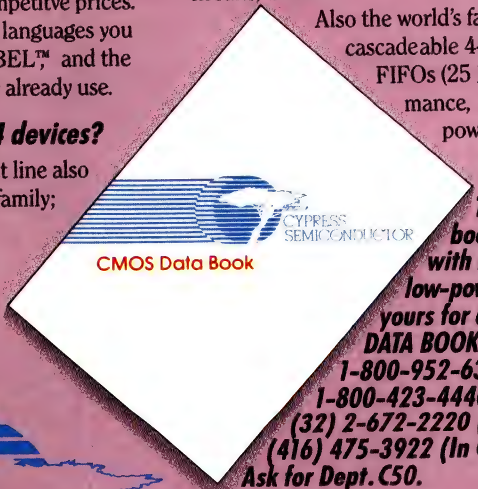

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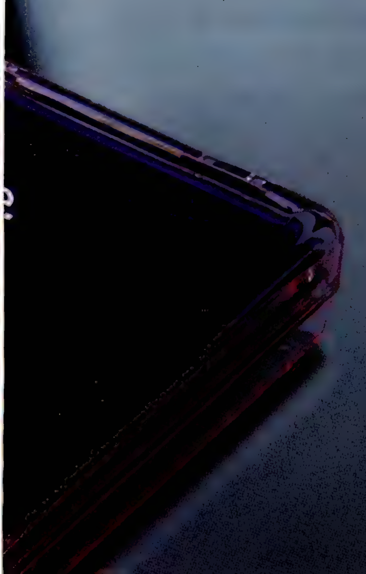

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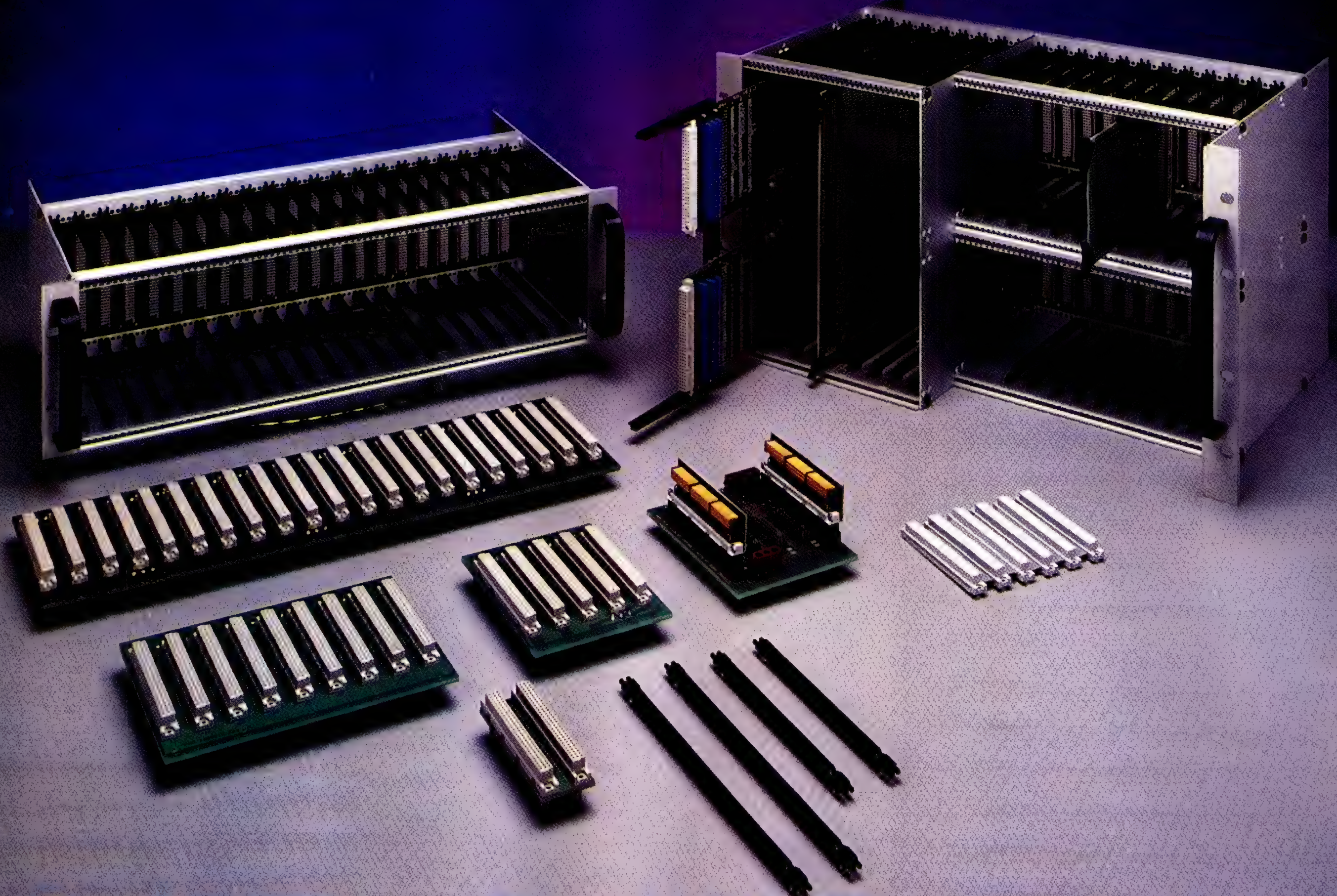

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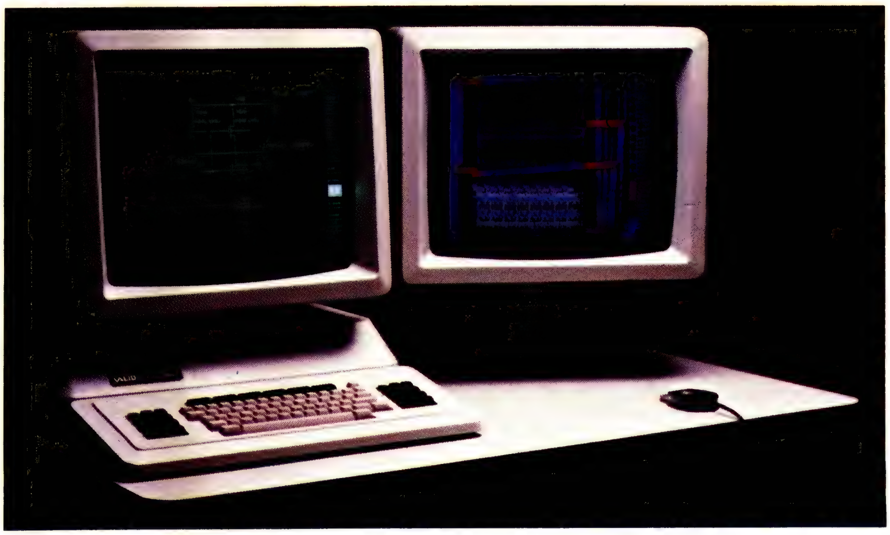
Specialized CAE/CAD hardware accelerators decrease run times for every design step

Eva Freeman, *Associate Editor*



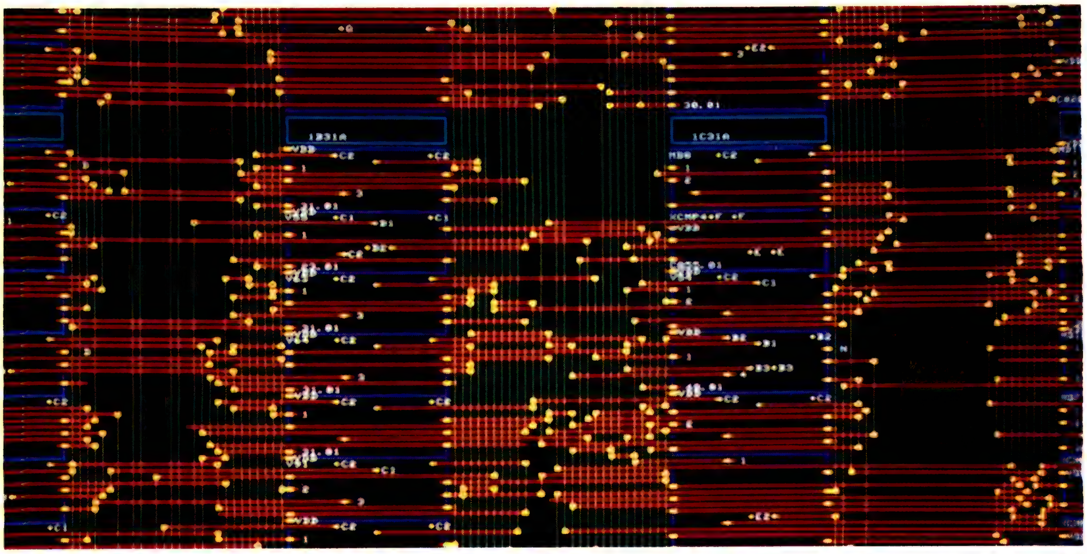
By adding the Realdraw graphics accelerator *to Valid's Scaldstar IC-design workstation, you can reduce redraw times to one or two seconds.*

You can now select a hardware accelerator to speed any stage of your computer-aided engineering and design projects. For CAE applications, companies including Shiva Multisystems and Weitek have introduced accelerators that simulate electrical circuits—these accelerators complement the logic-simulation accelerators pioneered by Zycad and Daisy. For CAD applications, you can turn to accelerators that can lay out pc boards or custom ICs.

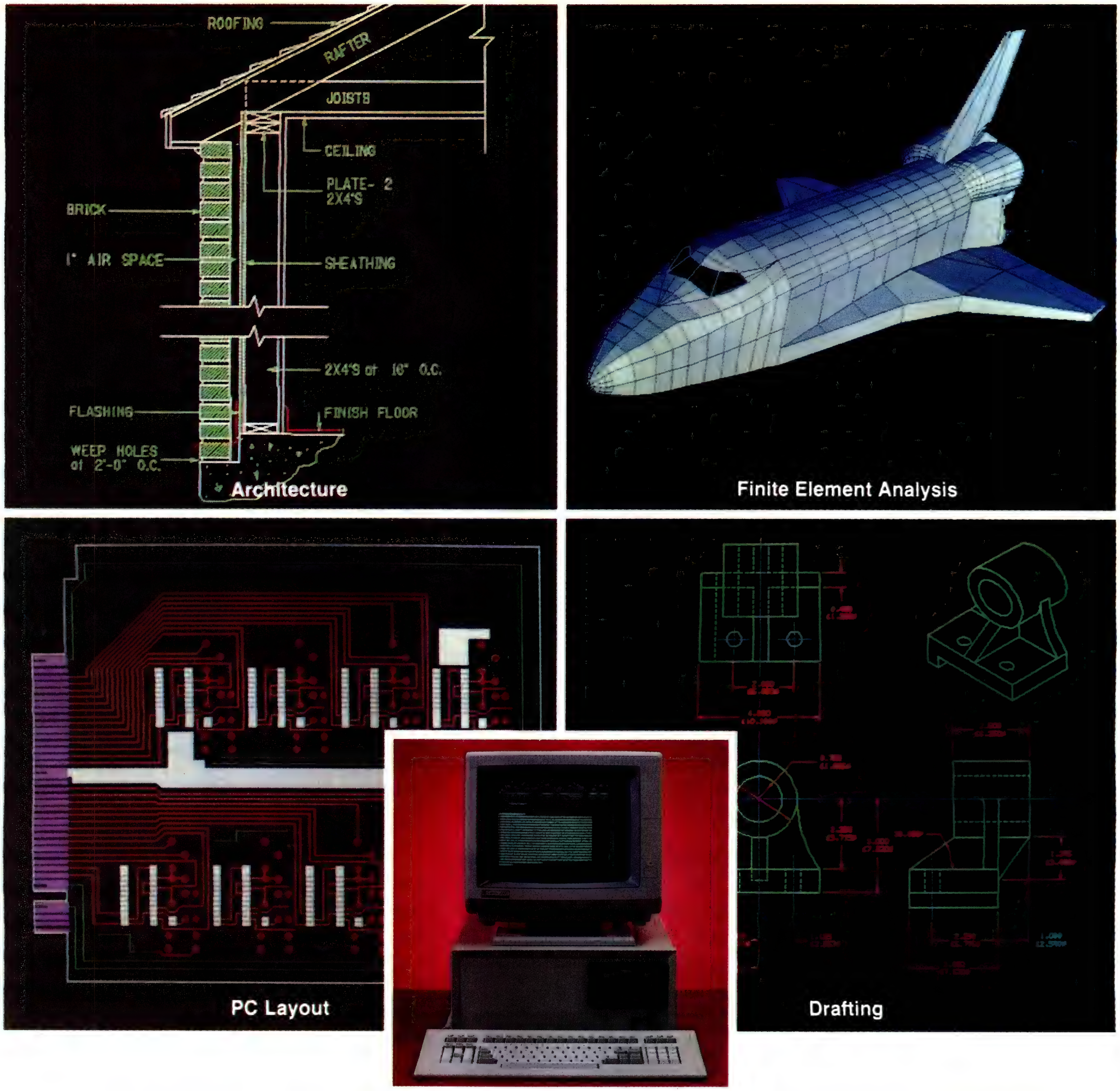
A hardware accelerator contains either a μP and a set of microcode instructions or a program encoded directly onto a custom IC. Because the hardware accelerator needn't interpret any software, it can run CAE programs as much as 1000 times faster than can a workstation or even a parallel-processing computer. Hardware accelerators generally take advantage of the parallel structure of CAE and CAD software by running several processes in parallel, an approach that contributes to their high speed.

But accelerators are expensive, and each one can run only a single CAE or CAD program. Moreover, you can update the program only by replacing the system's electronics. Thus, you must identify which design tasks are your greatest bottlenecks before you spend the $24,000 to $2.5 million that each stand-alone accelerator can cost.

Once you have selected the tasks that you need to accelerate, you should run benchmarks on several accelerators and select the system that best satisfies your requirements. All hardware-accelerator vendors can supply you with benchmarks, but keep in mind that each vendor chooses a design that favors its machines. Unless that design is typical of your designs, you won't be



Algorithms dedicated to placement *in Daisy's MegaGatemaster workstation accelerate gate-array design.*



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able to use the benchmark to predict the hardware accelerator's speed for your circuits. (See **box,** "Make sure you win the benchmark game.")

The need for benchmarks that adequately represent your designs becomes clear when you consider that raw computing power isn't the only factor that determines run-time. For example, in many analyses, I/O operations—instead of calculations—limit execution speed.

If, for instance, you use a hardware accelerator to simulate logic and you store the state of your circuit after every clock cycle, your actual calculation time will be negligible; the disk access time will determine the length of your simulation. If, on the other hand, you store the state of your circuit only infrequently, you won't care as much about disk I/O as you will about sheer computational power.

According to Silicon Solutions, a manufacturer of hardware accelerators, a hardware accelerator that's not optimized for I/O operations can spend 50% of its time recording 10% of the events that occur during a simulation. A hardware accelerator that a vendor has optimized for efficient I/O, on the other hand, requires as little as 7% of the run-time to record the same number of events.

I/O isn't the only process that can slow down a hardware accelerator—design compilation can also consume a substantial amount of time. To analyze a design that you have entered into a CAE workstation, a hardware accelerator must compile the design into a form that it can use. Especially for the complex circuits that necessitate a hardware accelerator, compilation times can be lengthy.

Many systems simulate logic

In the usual design cycle, you verify a design before you lay out the circuit. To verify a circuit, you must perform logical, fault, and electrical simulations. Partly because digital-logic simulation often

Make sure you win the benchmark game

A CAE or CAD vendor runs benchmarks for only one reason: to convince you that its system meets your requirements better than any other package. And, as long as the vendor performs an honest benchmark, you'll find that these evaluations usually do provide the best way to assess competitive systems. However, each company wants to sell its product, so you must make certain that you can trust your benchmark's results.

Richard Finn, president and chief executive officer of Calay, has developed a list of guidelines that can prevent a company from turning your benchmark into a high-tech con game:

1. Before you bring a benchmark to a vendor, run the same problem on your in-house system and document your results carefully. In addition to establishing a base line against which you can compare a system's performance, you can make sure that your problem does converge to an answer. Naturally, you should always submit your own design for a benchmark; a company can easily create a benchmark that favors its own system.
2. Don't supply any data to the vendor before you start the benchmark. A vendor that possesses advance information can prepare data and take care to hide any cumbersome functions. Worse still, the vendor can even run your problem before you arrive.
3. Insist on running a problem that typifies your needs. Often, a hardware accelerator can show faster performance for a circuit that is either more or less complex than your usual design, but you won't benefit from that performance. By analyzing a circuit that is typical for you, you can select the best hardware accelerator for you.
4. Interface the hardware accelerator to a system that is identical to yours. If you are planning to connect your hardware accelerator to an IBM PC, don't let the vendor control its hardware accelerator with a VAX 8600.
5. Attend the entire benchmark. Not only does attending the benchmark permit you to measure total run times, it enables you to observe any special maneuvers that may be necessary. Moreover, sometimes the last part of a run takes the longest time. If the run really is close to completion, then it shouldn't matter if you stay a few extra minutes; if several more hours elapse, then you know that the run really wasn't nearly complete.
6. Document the benchmark carefully. Unless you take meticulous notes, you won't be able to contrast the performance of different systems.
7. Change your design during the benchmark. You must be certain that you can implement design revisions quickly.
8. Give each vendor the same problem. If you have to modify your problem, rerun the revised problem on each system that you are considering.
9. Never pay for a benchmark. A vendor doesn't charge for a benchmark because it needs the money, it charges because it wants to discourage close examination of its system.

is the rate-limiting step in circuit design, hardware accelerators for logic simulation appeared first. Pioneers Zycad and Daisy have been joined recently by Silicon Solutions, Valid, Cadnetix, and Aida.

Silicon Solutions and Cadnetix both implement HHB Systems' Cadat logic simulator in their hardware accelerators. Cadnetix can interface its 200,000-event/sec CDX-7000 Simulation Engine into its CAE/CAD network for $59,900; Silicon Solutions charges $25,000 for its 250,000-event/sec Mach 100 and $100,000 for its 500,000-event/sec Mach 1000.

Other CAE companies also provide hardware accelerators for logic simulation; their systems incorporate Zycad's or Silicon Solutions' products. Among these CAE companies are Mentor, Silvar-Lisco, and Tektronix, all of which sell Zycad's Logic Evaluator; and HHB Systems, which markets the Silicon Solutions Mach 1000 as the CATS Accelerator.

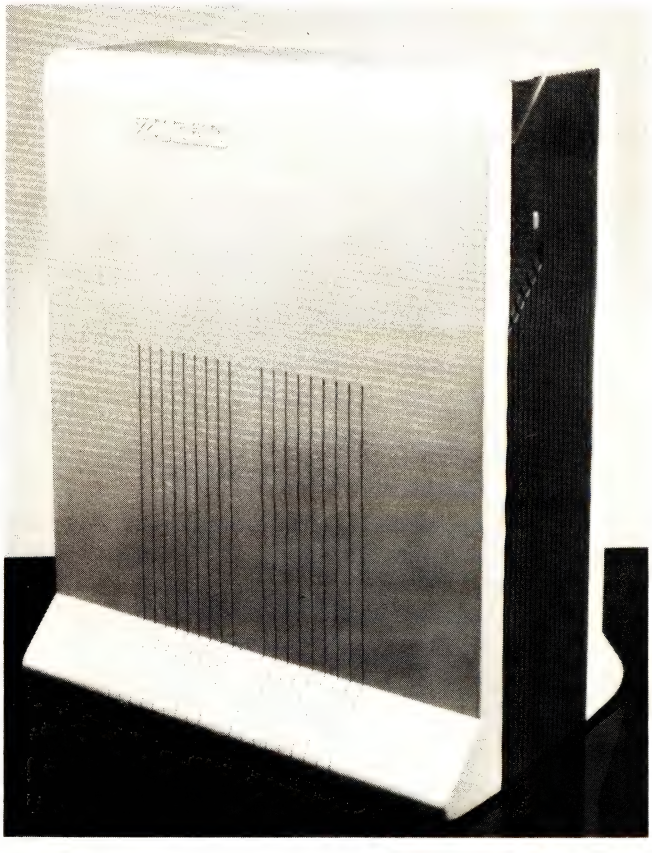
Zycad's hardware accelerators provide logic-simulation speeds ranging from 1G events/sec, for the $2.5 million System Development Engine (SDE), to 200k events/sec, for the Sprintor. Unlike most hardware accelerators, which are standalone add-ons to workstations or minicomputers, Sprintor is a pc board that plugs into personal computers or workstations. The company sells Sprintor only to OEMs, but you can obtain the product from Tektronix, which packages Sprintor into its $8000 TurboSim AT.

To fill in the gap in simulation speed between Sprintor and SDE, Zycad offers several versions of its Logic Evaluator and its Expeditor hardware accelerators. These systems can model from one million to 16 million events/sec; prices start at $95,000.

The number of events per second that a company quotes for its logic simulator can become another trap for the unwary. Zycad's simulation speed refers to the number of output state changes that the hardware accelerator can process in one second. Other firms quote gate evaluations per second, a figure that you must divide by about 2½ to equal output events per second. Some vendors also cite the number of equivalent gates per second that their hardware accelerators can simulate when the systems evaluate behavioral models; you can't relate this number to the performance of a system because you don't know how many gates the behavioral model replaces.

Although the number of events per second that a logic simulator can evaluate indicates a system's speed, you can get a better feeling for a system's speed by examining a vendor's published benchmarks. For example, you probably can't translate

An accelerator board, a parallel-processing computer, *and software that runs faster than Spice constitute Shiva Multisystems' SX Series circuit simulator.*



This turnkey digital-logic simulation accelerator, *the Zycad Expeditor, evaluates designs that contain as many as 50,000 gates at a speed of one million events per second.*

TEK 7854/7D20 TIME & AMPLITUDE
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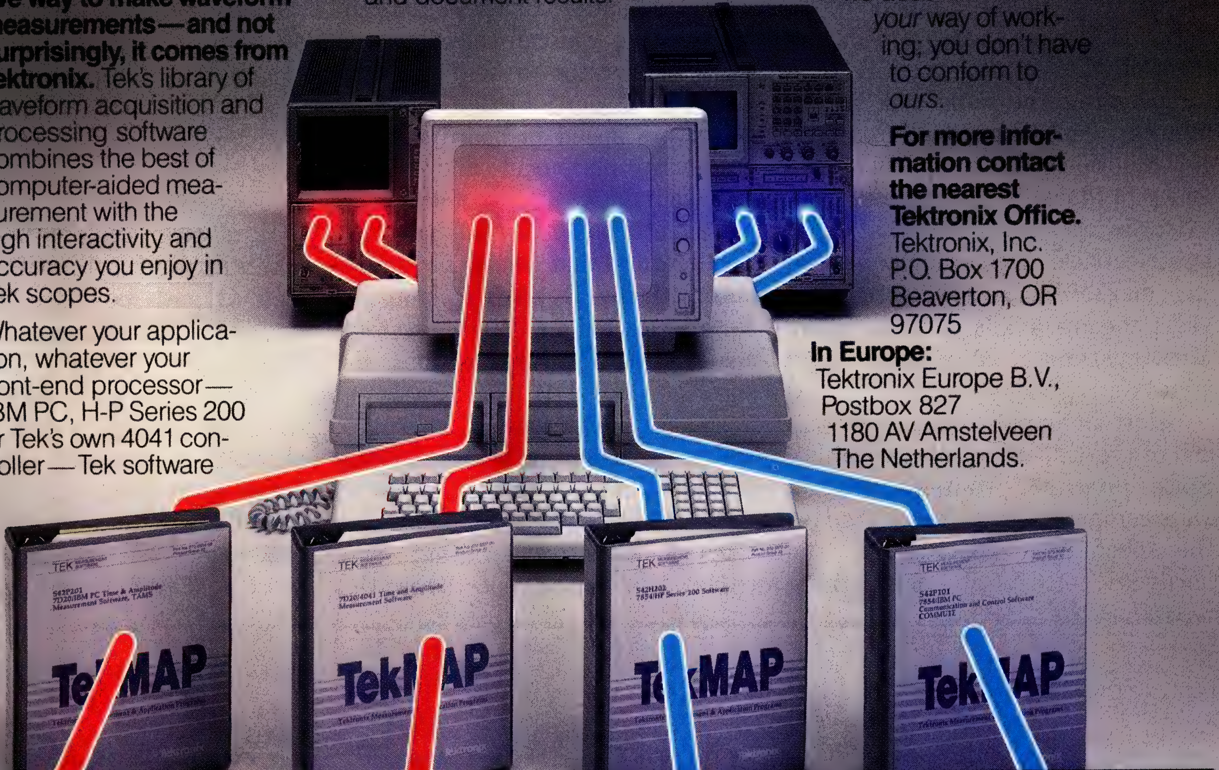

Now there's a faster, more repeatable and more productive way to make waveform measurements—and not surprisingly, it comes from Tektronix. Tek's library of waveform acquisition and processing software combines the best of computer-aided measurement with the high interactivity and accuracy you enjoy in Tek scopes.

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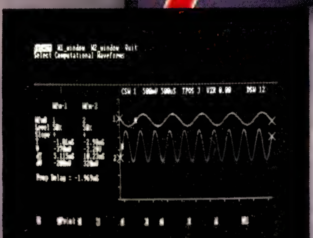
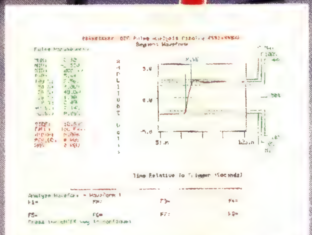
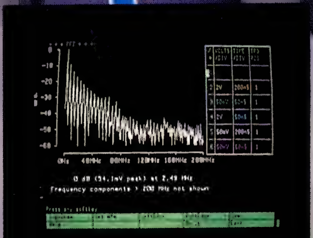


Delay time measurement using an IBM PC/XT/AT as controller with Tek's Time and Amplitude Measurement Software. Instruments: the Tek 7D20 Programmable Digitizer and Tek 7603 oscilloscope.



Automated pulse parameter analysis using a Tek 4041 Controller and Tek Time and Amplitude Measurement Software to direct the efforts of the 7D20 in a 7603 mainframe. Hard copy generated by a Tek 4695 Color Copier.



Computing and displaying frequency domain data (FFT), using an HP Series 200 Technical Computer as controller. Tek software for these results accommodates the HP Series 200 with the Tek 7D20 or the Tek 7854 Waveform Processing Oscilloscope.

Editing a Tek 7854 RPN program, including comments, for downloading to the 7854 or archiving to disk. Performed with the HP 200 Series Technical Computer, the Tek 7854, and Tek 7854/HP Series 200 Software. Similar facility available in COMMUTE.

Tektronix
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Copyright © 1985, Tektronix, Inc. All rights reserved. KSA-649-1 the 500,000-event/sec speed of a Mach 1000 directly into a run-time. However, the company reports that to debug one 8-pole digital-filter circuit that contains 20,200 transistors and 33,000 modeling elements, the Mach 1000 simulates 1000 vectors in 1.3 minutes; a VAX 11/780 requires 10 hours to duplicate this task.

Hardware accelerators can decrease fault-simulation run-times as much as they shrink logic-simulation times. In one benchmark, a VAX 11/780 requires 6.6 hours to inject 11,784 faults into a 6362-element circuit. Zycad's Fault Evaluator performs the same task in 9.85 minutes. Fault simulators from Silicon Solutions, HHB Systems, and Daisy produce similar results.

Hardware accelerators that simulate electrical circuits have entered the market only within the last year; they're available from Shiva Multisystems, Microsim, and Weitek.

Using an implementation in silicon of the University of California's Spice program, Weitek's product runs computations at 20 to 50 times the speed of a VAX 11/780. The hardware consists of a set of three Multibus boards built around pipelined 64-bit floating-point chip sets. In OEM quantities, the Spice accelerator costs $25,000.

Shiva's hardware accelerator simulates circuits about 100 times faster than a VAX 11/780. The package comprises a hardware implementation of PowerSpice (a fast version of Spice) and a parallel-processing computer. Systems range from $125,000 to $350,000.

After you have completed the CAE (simulation) phase of your circuit design, you can select a hardware accelerator to help you with the CAD (layout) portion. Such accelerators speed pc-board routing, gate-array placement, and custom-IC layout.

Cadnetix and Calay sell hardware accelerators that route pc boards automatically. By using a rip-up and reroute technique, these systems achieve 100% routing for most designs.

Unlike most routing packages, which analyze pc-board routing problems in layer pairs, Cadnetix's CDX-75000 Route Engine-Plus contains a multilayer routing algorithm. The vendor reports that this router inserts 573 vias in one 311-equivalent-IC pc-board design; the vendor's 2-layer router requires 1519 vias to design the same board. The $77,000 system interfaces to Ethernet; you can integrate the company's routing accelerator, its simulation accelerator, and its physical-modeling system on a single network.

Calay sells its routing engine in two forms: as the stand-alone RPR-300 off-line router and as a component in the V04 CAD system. The stand-alone engine costs $24,000; the CAD system, which includes a DEC PDP 11/73 computer, costs $179,980.

Accelerators speed IC layout

Hardware accelerators can help you with semicustom-IC design as well as with pc-board layout. By taking a statistical approach to gate placement, Daisy's MegaGatemaster can automatically place all the gates in a gate array. In general, such an approach is slow compared with other approaches, but MegaGatemaster's hardware accelerator increases the speed of the process. The $143,000 system uses

For more information . . .

For more information on the hardware accelerators described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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Calma Co
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Daisy Systems Corp
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Circle No 697

HHB Systems
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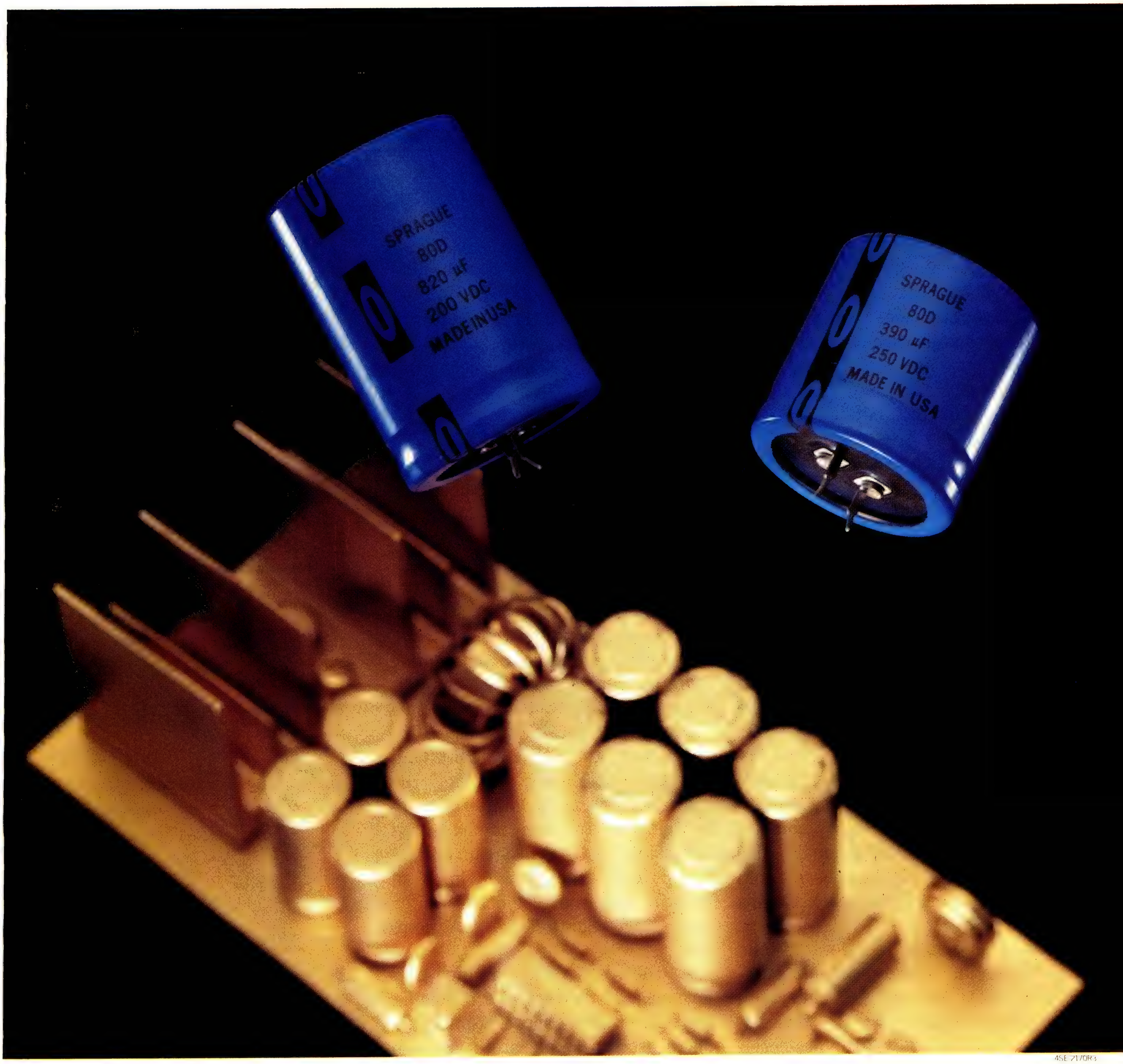

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the same hardware as the company's MegaLogician simulation accelerator, which also runs the company's MegaFault fault simulator.

Hardware-accelerator companies haven't forgotten to address the needs of custom-IC designers. Hardware accelerators can eliminate bottlenecks not only in custom-IC layout but in layout verification as well.

When you lay out a custom IC on your computer screen, you generally find that redrawing the layout is a major bottleneck in the process. Most layout systems require several seconds to implement a zoom or pan instruction. Because these interruptions are too long to let you continue working, but too short to let you take a break, redrawing a layout can easily disrupt your concentration.

Fast graphics aids IC layout

Silicon Graphics' Iris workstation offers an alternative to waiting for your layout to reappear. This workstation includes two custom-VLSI circuits that accelerate the computer's graphics. The chips scale and rotate images at a rate of 86,300 floating-point coordinates per second. Phoenix Data Systems' (Albany, NY) IC-layout and -verification program, Icap, runs on Silicon Graphics' workstations; by combining Icap and Iris, you can make sure that redrawing a layout doesn't hold up your work. The workstations start at $24,900.

Valid has also accelerated the graphics in its workstations. Running in the company's dual-screen Scaldstar custom-VLSI workstation, the Realdraw graphics-accelerator board increases the drawing speeds of layouts by an order of magnitude. Redrawing typically takes one or two seconds. The graphics accelerator features a 68020 µC that handles graphics exclusively. You can add Realdraw to your Scaldstar workstation for $10,000.

Hardware accelerators can speed the final step in an IC layout: verification of the layout. If you lay out your ICs on a Calma GDS II CAD system, you can use the Fast-Mask Engine, a hardware accelerator that uses parallel 68020-processor boards to check IC layouts for design-rule violations. It runs these checks in the background on the CAD system's Data General computer, without degrading the GDS II's speed in the foreground. According to the vendor, the hardware accelerator decreases the verification time of a 40,000-transistor µP from 72 hours and three minutes on an unaccelerated system to one hour and 10 minutes. The basic system starts at $60,000.

Competition from computers

More accelerators are due to appear on the market, and these systems should implement more CAE/CAD functions. However, the future of hardware accelerators is unclear. On the one hand, no other system provides the sheer speed of these systems. On the other hand, high-speed computers are becoming more affordable, and these computers don't lock you into a single program.

Mentor and AT&T OmniCad (Pittsford, NY) are pursuing the high-performance computer approach. Mentor has implemented several of its CAE programs on its Compute Engine; AT&T OmniCad runs its Omniroute pc-board router on a Ridge (Santa Clara, CA) computer.

At the same time that high-performance computers are becoming more affordable, the custom-VLSI parts used in accelerators are also decreasing in price. Hardware accelerators might not give up their role in CAE and CAD; they might simply become inexpensive add-ons.

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VP611. Identical to VP601 plus 16-key numeric keypad for easier entry of numbers. $157*.

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VP616. All features of VP606 and VP601 in a serial output format, with 16-key numeric keypad. $194*.

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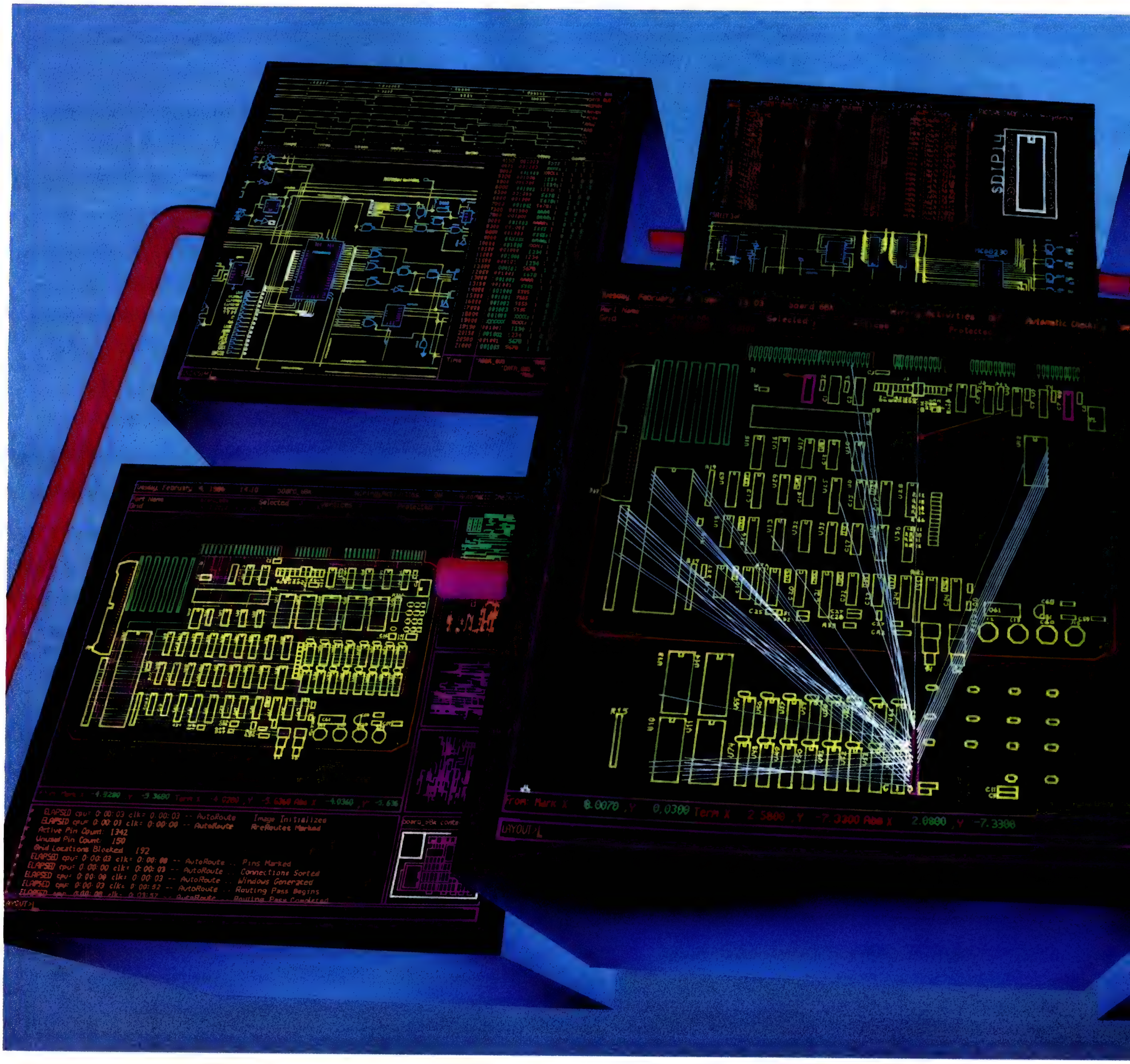
VP601
VP606

VP611
VP616

RCA New Products Division

CIRCLE NO 51

Only Mentor Graphics puts PCB layout where it belongs.



Until now, printed circuit board layout was an isolated process: done on a special-purpose workstation at the "back end" of the design effort. But Mentor Graphics saw it a different way. Since PCB layout brings together all the elements created by "front end" CAE tools, it should be integrated with those tools.

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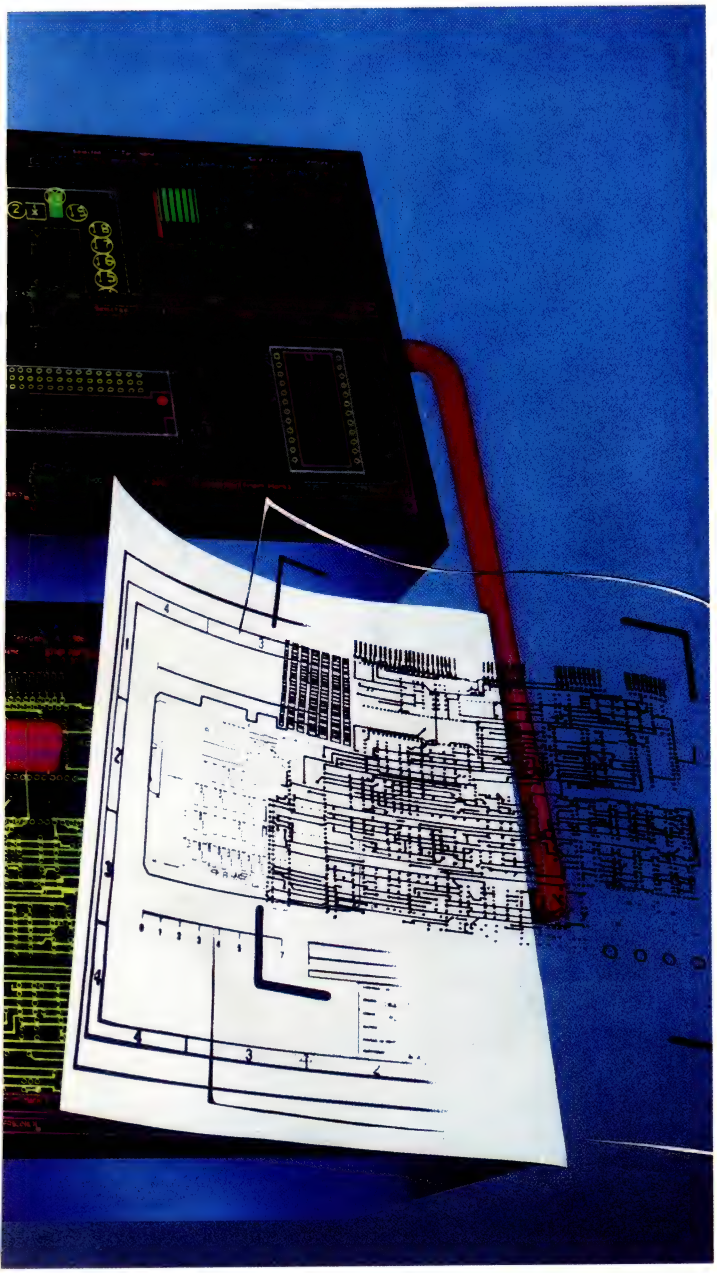
At last, PCB layout resides in a CAE network that also includes hierarchical schematic capture, as well as logic and analog simulation. All linked in an environment that permits fast, simple data sharing for greater productivity.



As for the tools themselves, a very fast and efficient routing system optimizes board usage and minimizes manufacturing overhead. Now you can do both automatic and interactive fine line routing on even the most complex multi-layer boards. A double-sided placement editor presents a complete view of components on either side of the board under design.

And you have the ability to work with almost any type of component package to optimize your design to meet current market requirements.

Also, our PACKAGE tool bridges, at long last, the gap between EE and PCB designers. Any electronic design is automatically translated into proper component packaging.

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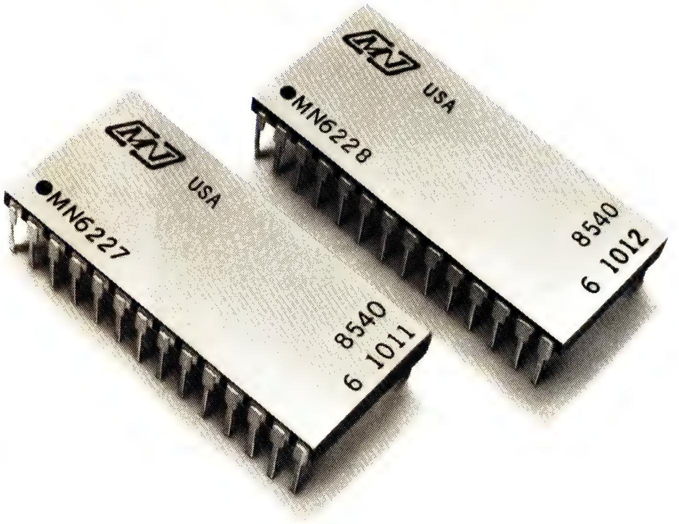
33kHz 12-BIT DSP A/D's

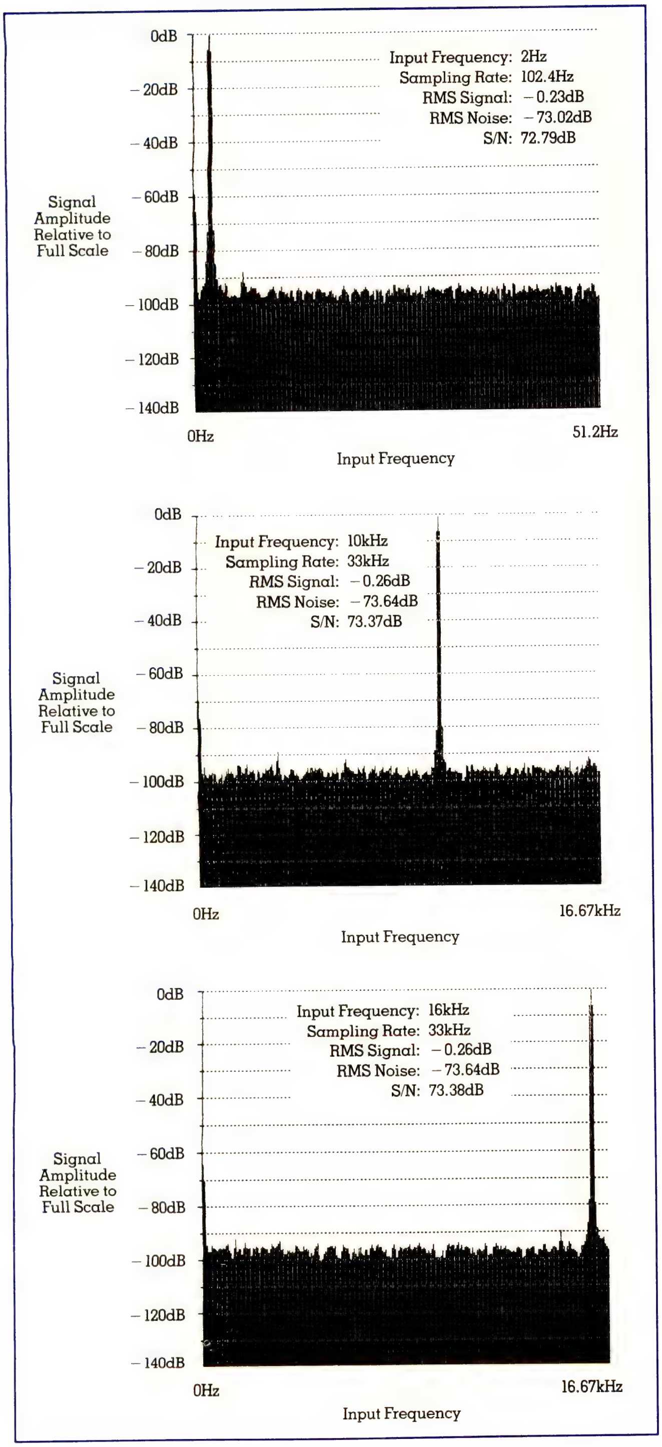


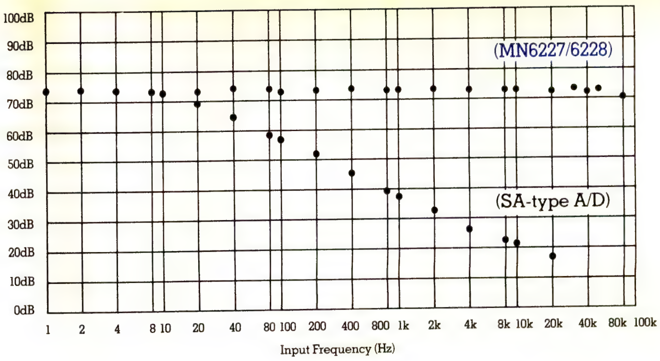
MN6227/MN6228

12-Bit Sampling A/D's
Sampling Rate: 33kHz Minimum
Input Bandwidth: 16.5kHz Minimum
Testing: Frequency Domain (FFT)
Signal-to-Noise Ratio: 70dB Minimum
Harmonics: −80dB Minimum
Price: $74/100's

You are looking at the *first* commercially-available, *FFT-tested*, high-speed, 12-bit, sampling A/D converters *specified* for digital-signal-processing applications. MN6227 and MN6228 are 33kHz A/D's with internal track-and-hold amplifiers. They are ideally suited for radar, sonar, spectrum and vibration analysis, voice and signature recognition, and other contemporary DSP applications. Unlike traditional successive-approximation A/D's without track-hold amplifiers, these true sampling A/D's maintain near-ideal signal-to-noise ratios independent of increasing analog input frequencies. They are *made* for the frequency domain.

Note the FFT spectra (right) and the data plot (top right). They clearly demonstrate the ability of these devices to maintain SNR with increasing input frequencies. In our frequency-domain testing, these devices operate in a manner that simulates a digital spectrum analyzer with a known low-distortion input signal. The output spectra yield precise, practical measurements of signal level, noise level, signal-to-noise ratio, harmonic distortion, and input bandwidth… the keys to specifying for DSP applications.

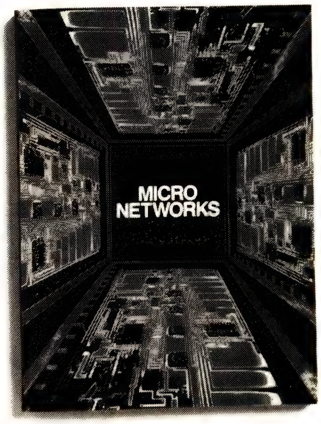




This plot of actual recorded data demonstrates MN6227/6228's ability to maintain near-ideal SNR with increasing input-signal frequency, while A/D's without companion track-holds show rapid (6dB/octave) SNR degradation.

MN6227/6228 are the first A/D's in our new MN6000 series. The 12 and 16-bit converters in this series all contain internal, user-transparent, track-hold amplifiers that enable each device to accurately sample and digitize dynamically changing input signals with frequency components up to the Nyquist frequency (one-half the sampling rate).

MN6227/6228 have a full 8 or 16-bit µP interface and are packaged in small, low-profile, 28-pin ceramic DIP's, with the industry-standard MN574A pinout.



For detailed information on MN6227/6228, send for our comprehensive data sheet. For rapid response and a copy of our 384-page catalog of data conversion products, call Bob LeFort at (617) 852-5400, x297.

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Advancing Data Conversion Technology

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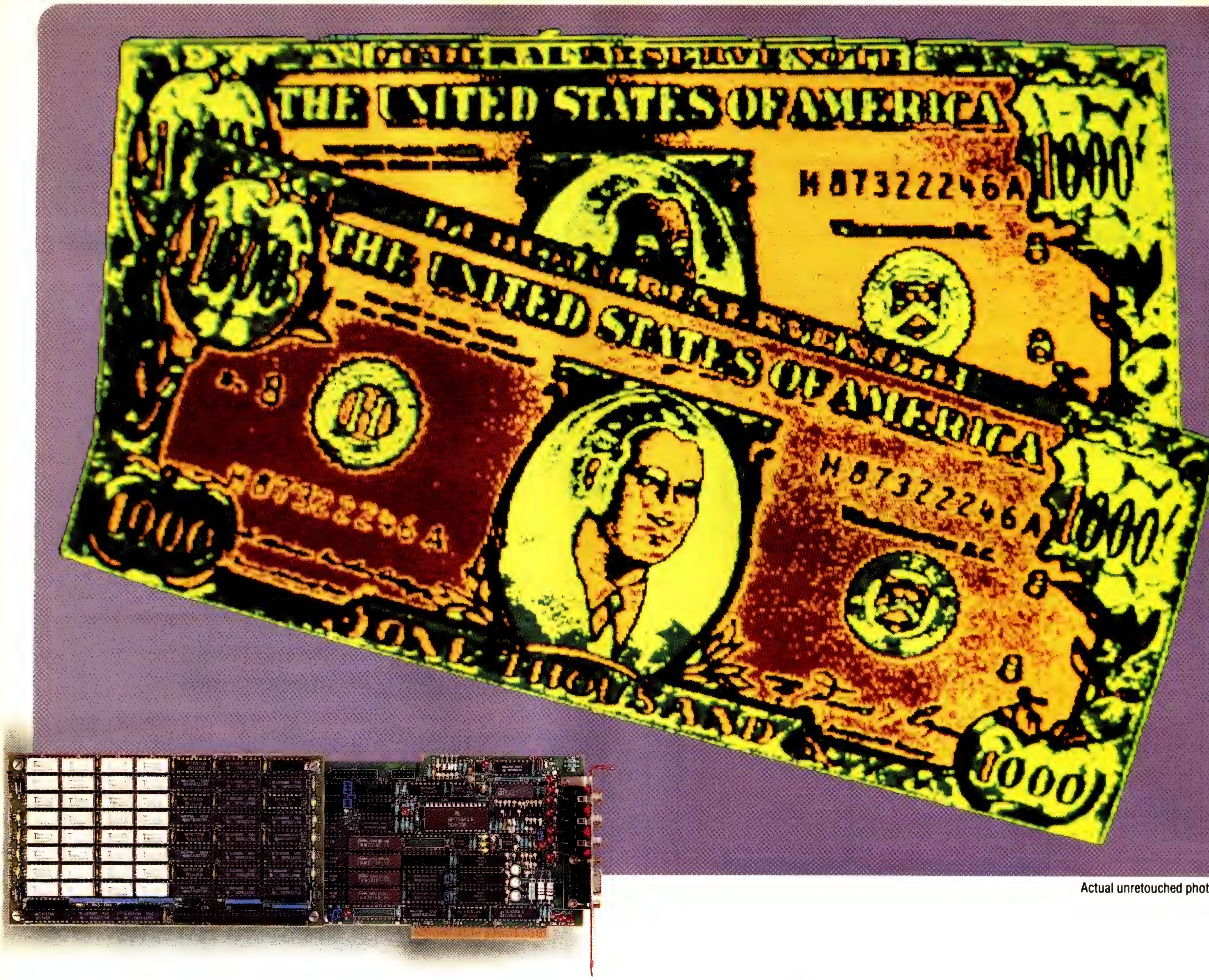
CIRCLE NO 52



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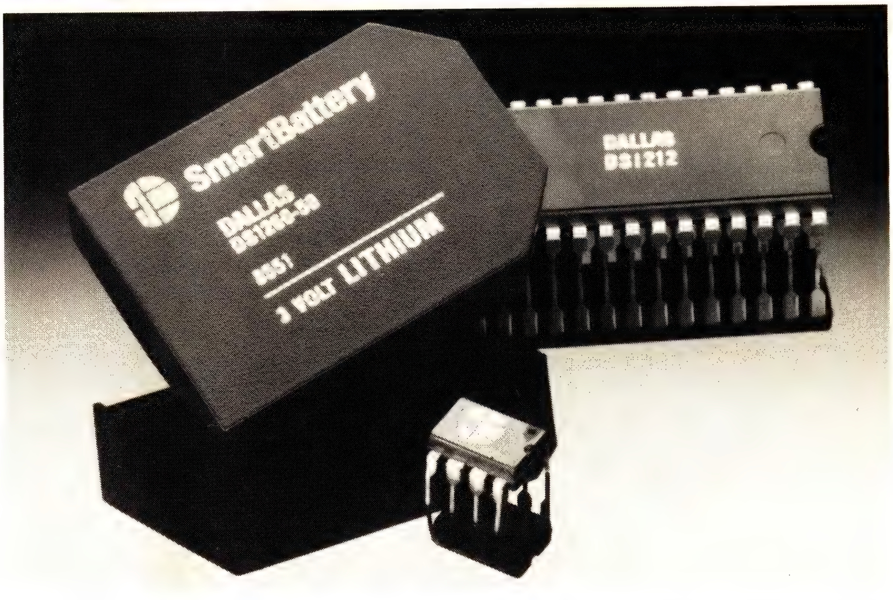
CIRCLE NO 53

CMOS chip set monitors for power failures and protects against data loss

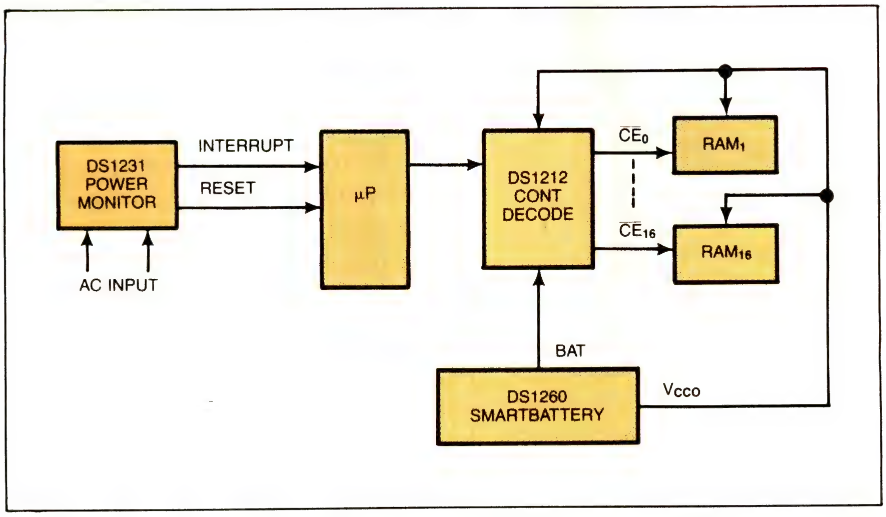
Providing orderly shutdown and automatic restart for μP-based systems, the Integrated Battery Backup (IBB) 3-part chip set protects critical data during a power loss. The chip set is more than just a board-level battery for your computer's volatile RAM—it allows your system to continue a task where it left off, as if no power disruption had occurred.



To protect a μP-based system from data loss, *the Integrated Battery Backup chip set monitors the high-voltage inputs to the system's power supply and halts μP activity as soon as power drops below a user-selectable 5 or 10% threshold, giving the processor time to store data in nonvolatile RAM before an actual power failure.*

The IBB comprises the DS1231 power monitor, the DS1260 SmartBattery, and the DS1212 nonvolatile controller/decoder. The DS1231, which monitors the high-voltage inputs to your system's power supply, warns the system's μP of an impending power failure. Using a temperature-compensated reference circuit to compare line voltage and V_{CC}, the DS1231 unconditionally halts the μP when V_{CC} falls below a user-selectable 5 or 10% voltage threshold. By halting μP activity before an actual power failure, the DS1231 gives the processor time to store data in nonvolatile RAM.

When the line voltage returns, the DS1231 continues to hold the μP inactive until power conditions stabilize, thus preventing the processor from accidently emitting write signals, which could change the data stored in RAM. When line power meets the power monitor's nominal specifications, the chip restarts the μP. You can interface a UL-approved optoisolator directly to the DS1231.



The DS1231 power monitor warns a system's μP *of an impending power failure so that the μP can store critical data before a power loss. When line voltage falls below a critical level, the DS1260 supplies battery power to the RAMs. The DS1212 determines which power source will best maintain the RAM data; this chip also guards data integrity during power transients.*

The DS1260 SmartBattery's encapsulated lithium energy cell refreshes RAM data during a line-voltage power loss. As soon as V_{CC} exceeds the 3V battery output, the line voltage again supplies power to the system. The chip maintains its 3V potential. Capable of providing more than 10 years of power, the 3V SmartBattery comes in 250, 480, and 960 mAhr capacities.

The DS1260 has an isolation feature that prevents the battery's power capacity from dropping during shipping and handling. The chip's pins are recessed to prevent bending. Further, even when it's plugged into the circuit, the lithium cell will electrically disconnect from the chip's exposed pins when you pulse the chip's reset input. Although the power chip's dimensions are relatively large (1.50×1.05×0.41 in.), the DS1260 plugs into a standard 16-pin DIP socket.

The third part of the IBB chip set, the DS1212 nonvolatile controller/decoder, can convert as many as 16 CMOS static RAMs to nonvolatile memories by automatically switching supply voltage from V_{CC} to the DS1260 when a power failure occurs. Like the DS1231 power monitor, the DS1212 monitors incoming power for any out-of-tolerance condition. If it detects such a condition, the DS1212 inhibits its chip-enable pins, providing write protection for the RAMs. The chip holds each RAM's chip-enable input to within 0.2V of V_{CC} or the battery voltage, whichever is greater. When battery voltage exceeds V_{CC}, the chip shunts battery power to the RAMs for uninterrupted data refreshing.

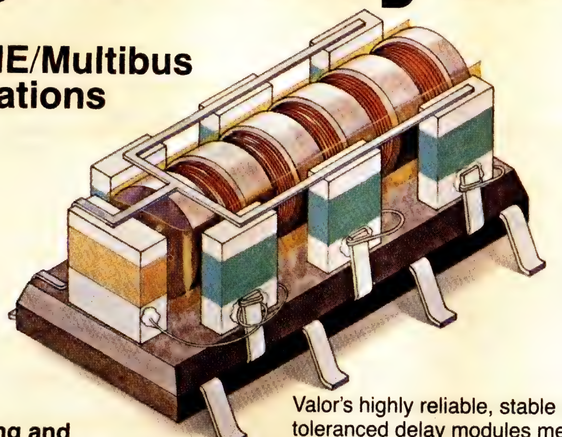
You can use the power-failure signal from the DS1212 to interrupt the system's μP when V_{CC} falls below a user-selectable voltage from 4.75 to 4.25V. Further, every time you apply power to the circuit, the DS1212 performs a battery test to verify that the battery's voltage is greater than 2V. The DS1212 can accommodate as many as two batteries; the chip tests each battery's condition during the battery-backup operation and uses the battery with the higher voltage. If one battery should fail, the other will assume the load. DS1231, $3.30; DS1260, from $6.25; 16-RAM DS1212, 6.70 (1000).—***J D Mosley***

Dallas Semiconductor Corp, 4350 Beltwood Parkway, Dallas, TX 75244. Phone (214) 450-0400.

Circle No 731

Digital Delay Lines

For VME/Multibus Applications



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Valor's highly reliable, stable and close-toleranced delay modules meet asynchronous data transfer rates in your multiprocessor interface by tightly controlling the leading/trailing edges of the data stream. Both surface mount and standard configurations are available.

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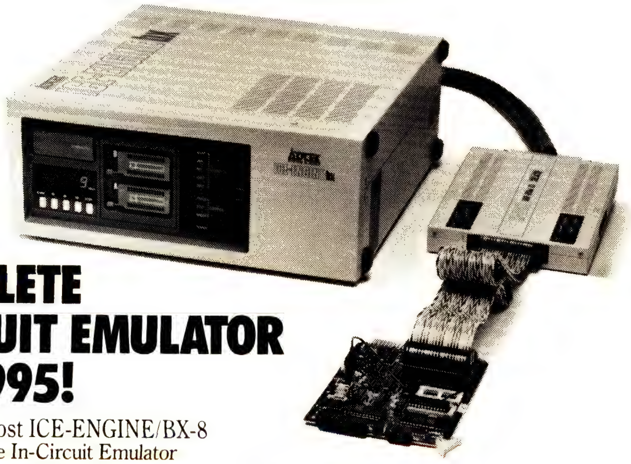
CIRCLE NO 54



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CIRCLE NO 55

Burst the price/ performance barrier!

Philips proves that high performance doesn't necessarily mean high price. The PM 5193 is the most competitively-priced full-function 50 MHz-generator on the market. Yet it outperforms the most expensive.

Just look at these features:

- **Extremely high accuracy** thanks to 8-digit resolution and crystal oscillator reference over the range 0.1 mHz to 50 MHz.
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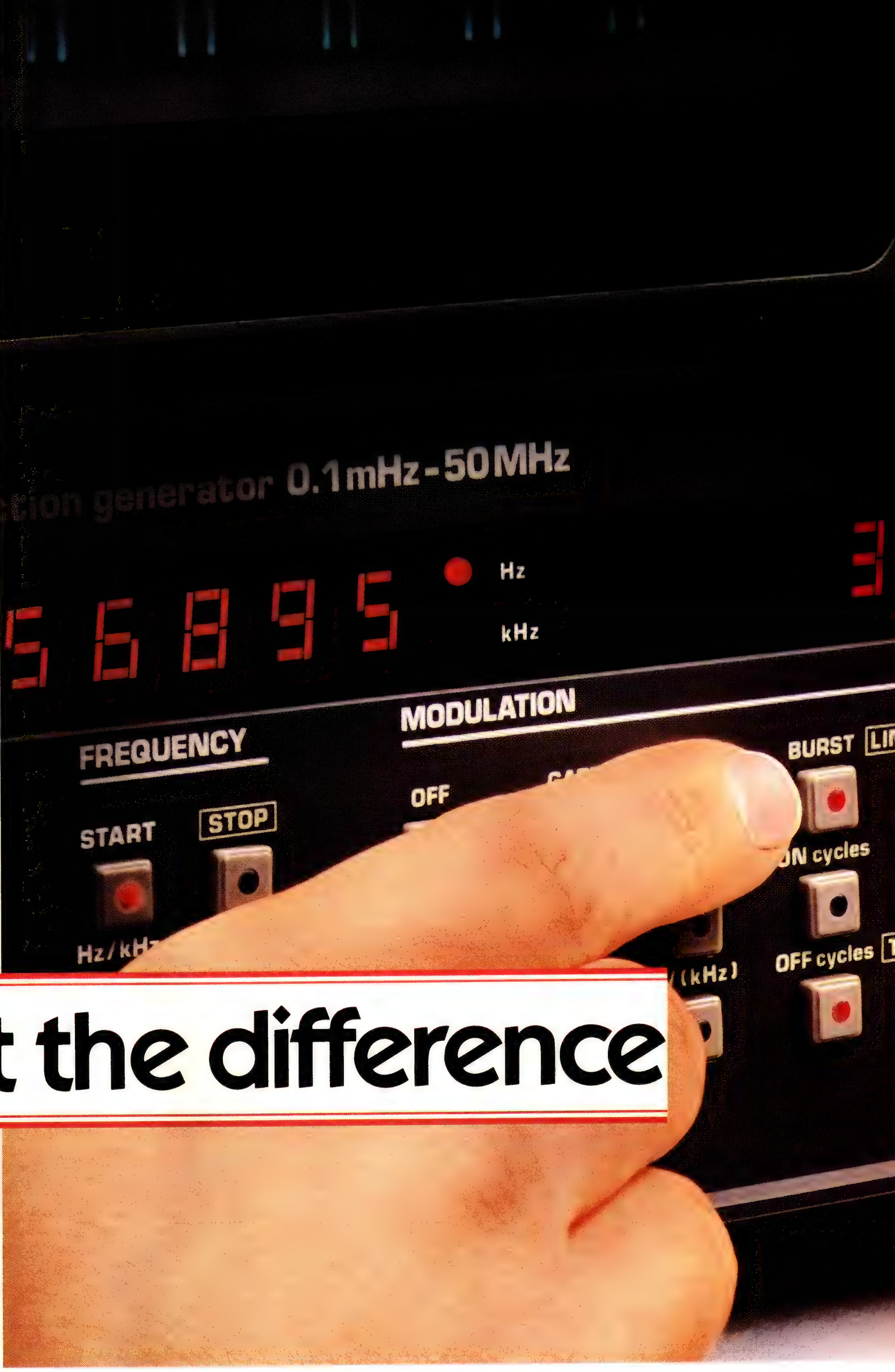

Test the difference

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CIRCLE NO 57

Ethernet Test:

What is the traffic loading of your Ethernet? Who is involved in data exchange?

Logic Analysis System LAS

The LAS and its Ethernet Test Probe make your network transparent.

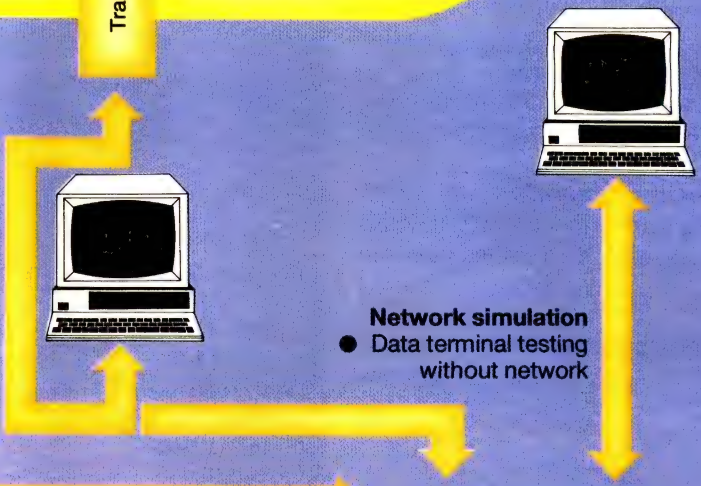
How long are the data packets?

Transceiver

Ethernet

Monitor mode

- Disassembled display of data traffic
- Selective collection (e. g. user addresses only)
- Automatic generation and testing of CRC word
- Measurement of data transfer timing
- Measurement of traffic loading by means of histogram display



Network simulation

- Data terminal testing without network

Transceiver

How often do collisions occur?

Generator mode

- Sending of test patterns
- Generation of collisions for checking network behaviour
- Simultaneous analyzer and generator operation

The LAS – not only a powerful tool for logic analysis but also ideal for LAN testing.

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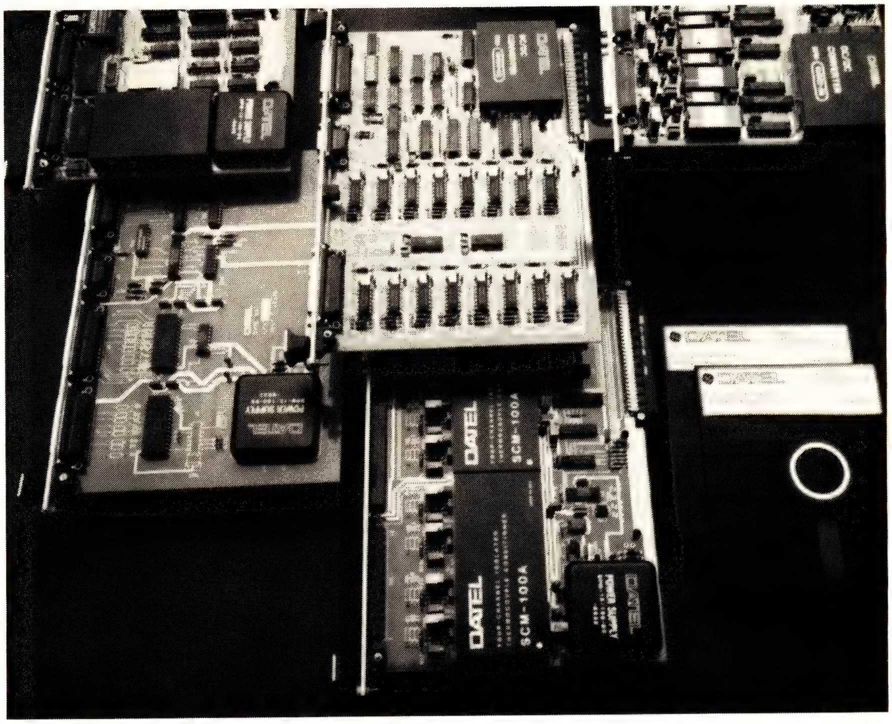
CIRCLE NO 16

VME Bus board family provides data acquisition and control



This family of VME Bus boards offers A/D and D/A conversion *and digital I/O communications. Some models provide conversion resolution as high as 16 bits and sampling time as low as 4 µsec.*

The DVME family comprises nine VME Bus boards that perform A/D conversion, D/A conversion, and analog multiplexing. When combined with the vendor's analog multiplexer boards and software packages, these boards can form the basis for data-acquisition and control systems.

The DVME-611 and -612 A/D conversion boards accept 32 single-ended or 16 differential analog inputs. You can choose from four versions having the following resolutions and conversion rates: 12 bits, 20 µsec; 12 bits, 4 µsec; 14 bits, 35 µsec; and 16 bits, 400 msec. You program the boards to convert single-channel or sequential inputs and to generate an interrupt at the end of a conversion. Each board includes a programmable-gain amplifier, which specs a gain of between 1 and 128, and an input-voltage range as wide as ±10V. The -612 has two additional 12-bit D/A channels.

The DVME-602, which has four isolated input channels, provides A/D conversion for thermocouples. It offers 1000V pk isolation and 12-bit resolution, as well as an additional sign bit. The board samples inputs at rates as high as 30 samples/sec. It provides linearized output data in °C or °F. The four versions of the DVME-602 accept different types of inputs.

For D/A conversion, the DVME-624 and DVME-628 provide 12-bit resolution and an optional 4- to 20-mA current-loop option. The DVME-624 provides four isolated channels that can accept voltages between −10V and +10V; the company guarantees 300V isolation between channels and between the channels and the VME Bus. Versions of the DVME-624 offer either 6- or 30-µsec settling times. The DVME-628 has eight channels and offers 6-µsec settling time.

The DVME-660 board offers 48 digital I/O channels that operate with TTL-level signals. It contains an onboard timer and circuitry for implementing internal and external interrupts.

The remaining three boards—the DVME-641, -643, and -645—are multiplexer boards that expand the number of input channels you can connect to the DVME-611 and -612. The DVME-641 includes 32 single-ended or 16 differential input channels. The DVME-643 offers eight 1000V-pk-isolated channels and provides signal conditioning for thermocouples. You can order conditioning modules for the DVME-643 to use RTD and strain-gauge sensors. The DVME-645 can accept 16 single-ended or eight differential inputs that are sampled by 10 S/H amplifiers.

All the DVME boards respond to addresses on 256-byte boundaries within the VME Bus's 64k-byte I/O space. Two software packages are available: the first comes with the boards and provides a diagnostic test program; the second, DVME-UTIL, contains subroutines for system configuration and I/O functions.

Prices for specific versions of the boards are as follows: DVME-611A, $1495; DVME-612A, $1595; DVME-602T, 1375; DVME-624V, $1145; DVME-628V, $1345; DVME-660, $795; DVME-641, $695; DVME-643T, $1435; and DVME-645, $1385. The DVME-UTIL software costs $385.—***David Smith***

Datel, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341.

Circle No 729

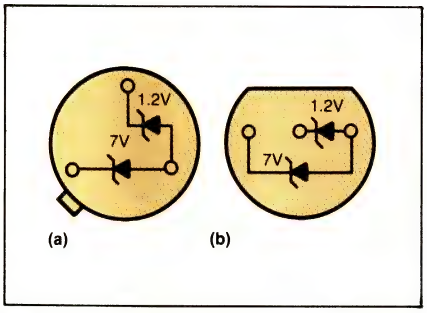
Dual voltage-reference and comparator ICs offer precision specs, draw little current

Two dual-section bipolar ICs provide precision performance while drawing low power-supply currents: Model LT1034 3-terminal voltage-reference circuit resembles a pair of 1.225 and 7V zener diodes connected in common-anode configuration; the LT1017/1018 Series dual comparators offer you a tradeoff between low operating power (LT1017) and high speed (LT1018).

Housed in a TO-46 metal can or a TO-92 plastic package, the LT1034 dual reference contains a low-drift (20 ppm/°C max), 1.225V zener-like reference that operates with currents from 20 μA to 20 mA. The IC also houses a somewhat less stable (40 ppm/°C typ) 7V reference that's specified for operation with currents from 100 μA to 20 mA.

Dynamic impedance for the LT1034's 1.225V section is specified in two ways. The first method gives maximum change in voltage over two current ranges: The device specs 2 mV max for currents from 20 μA to 2 mA and 8 mV max for currents from 2 to 20 mA. The second method gives incremental impedance at a 100-μA current: The device specs 1Ω max. For the 7V section, the IC yields 140-mV max change for currents from 100 μA to 1 mA and 250-mV max deviation for currents from 1 to 20 mA.

The LT1034's 1.225V section also offers ±15-mV voltage accuracy, 4-μV p-p typ noise (over 0.1 to 10 Hz), a 20-ppm/°C temperature coefficient, and 20-ppm typ long-term stability. The LT1034 is available in versions that operate over 0 to 70°C or −55 to +125°C and costs $2.15 to $2.85 (100) for commercial-temperature-range grades.



You can choose a metal can or a plastic package *for the LT1034 dual reference. These bottom views show the IC's pinouts in a TO-46 package* ***(a)*** *and a TO-92 package* ***(b)****.*

The LT1017/1018 dual comparators are pin compatible with existing industry-standard dual comparators. The LT1017, which is optimized for low power dissipation, draws 60-μA max supply current; the LT1018, optimized for high speed, consumes 250 μA max. For input signals providing 2-mV overdrive, delay time for the LT1017 is approximately 30 μsec for the signal's rising edge and 45 μsec for the falling edge. Under the same condition, respective delays for the LT1018 are approximately 9 and 10 nsec.

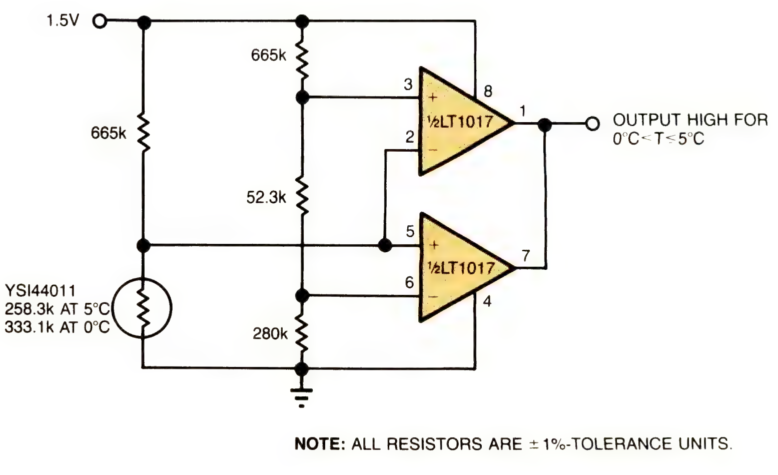
A useful feature of the two comparators is their class-B output stage. Most other comparators have an open-collector output that obliges you to use an external pullup resistor to provide positive-going outputs. The class-B output stages of the LT1017 and LT1018 provide automatic pullup. Further, because the comparators can operate from supplies as low as 1.1V, they can run on a single cell.

Voltage gain for both the LT1017 and LT1018 is 110 dB min. This high gain allows the comparators to change state when very-low-level input signals are applied. Offset voltage for both models is 1 mV max, and their common-mode rejection ratio is 105 dB min. Available in either 8-pin metal cans or in plastic DIPs, the LT1017 and LT1018 cost $2.10 and $1.95 (100), respectively.

—Bill Travis

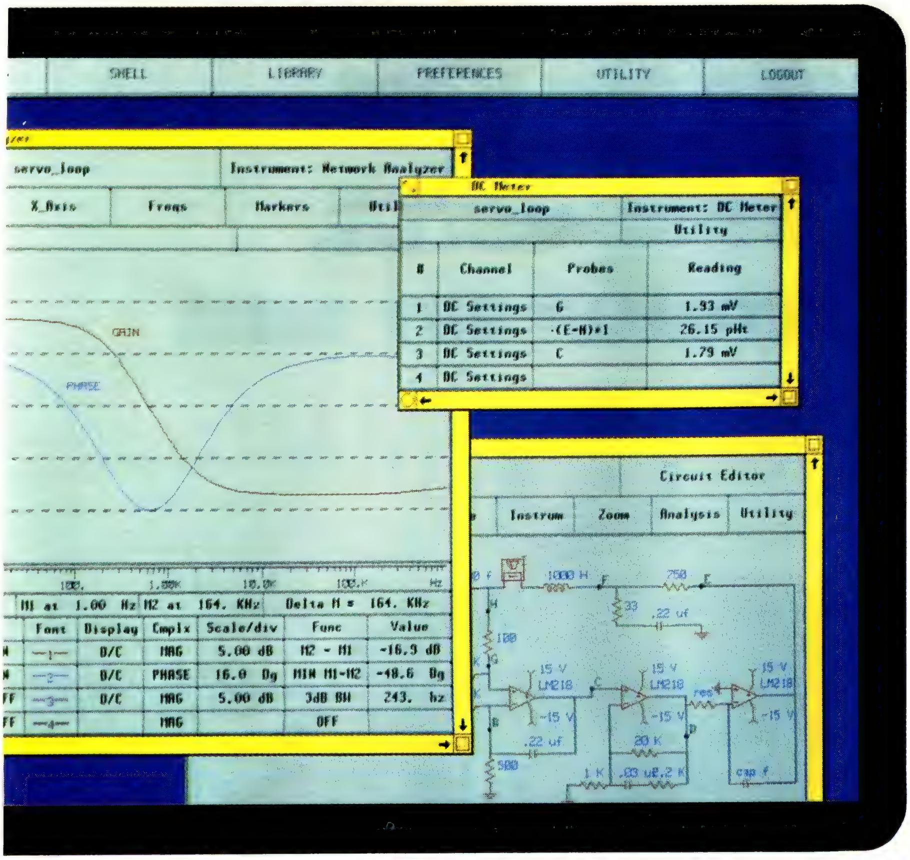
Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 942-0810.

Circle No 726



NOTE: ALL RESISTORS ARE ±1%-TOLERANCE UNITS.

Low power consumption and low-supply-voltage capability *make the LT1017 suitable for use in this refrigerator-alarm circuit. The alarm trips when the refrigerator's temperature goes below 0°C or above 5°C.*



#	Channel	Probes	Reading
1	DC Settings	6	1.93 mV
2	DC Settings	·(E-H)*1	26.15 pHt
3	DC Settings	C	1.79 mV
4	DC Settings		

M1 at 1.00 Hz M2 at 164. KHz Delta M = 164. KHz

	Font	Display	Cmplx	Scale/div	Func	Value
N	—1—	D/C	MAG	5.00 dB	M2 - M1	-16.9 dB
N	—2—	D/C	PHASE	16.0 Dg	MIN M1-M2	-48.6 Dg
FF	—3—	D/C	MAG	5.00 dB	3dB BW	243. hz
FF	—4—		MAG		OFF	

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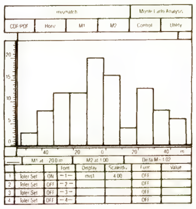
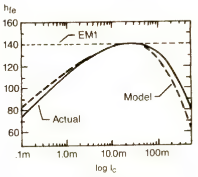

Monte Carlo Analysis predicts manufacturability.



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ANALOG
DESIGN
TOOLS

CIRCLE NO 41

IN A WORLD FULL OF ANOMALIES WE'VE FOUND ONE MORE, THE STANDBY UPS DESIGNED BY COMMITTEE.

SOME FOLKS ACTUALLY BUY THEM

OTHERS BUY CCI'S FAILSAFE AC AND DC INPUT UPS WITH ON-BOARD BATTERY CHARGER

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CIRCLE NO 60

32-bit single-board computer includes graphics, networking, and I/O circuits

The 68020 Uni-System computer combines the 32-bit 68020 µP, I/O ports, memory, and optional graphics and networking circuits on a triple-height VME Bus board. The company will configure the board to your specifications. The basic 68020 Uni-System includes the 68020 (running at 16.7 MHz), a 68851 paged MMU, 2M bytes of RAM, and sockets for as many as 128k bytes of ROM. You can expand the memory to 8M bytes and add a 68881 floating-point processor. In addition, because the board can use a 20-MHz clock signal, you'll be able to replace the µP with a 20-MHz version when one becomes available. Six DMA channels provide onboard or offboard memory transactions.

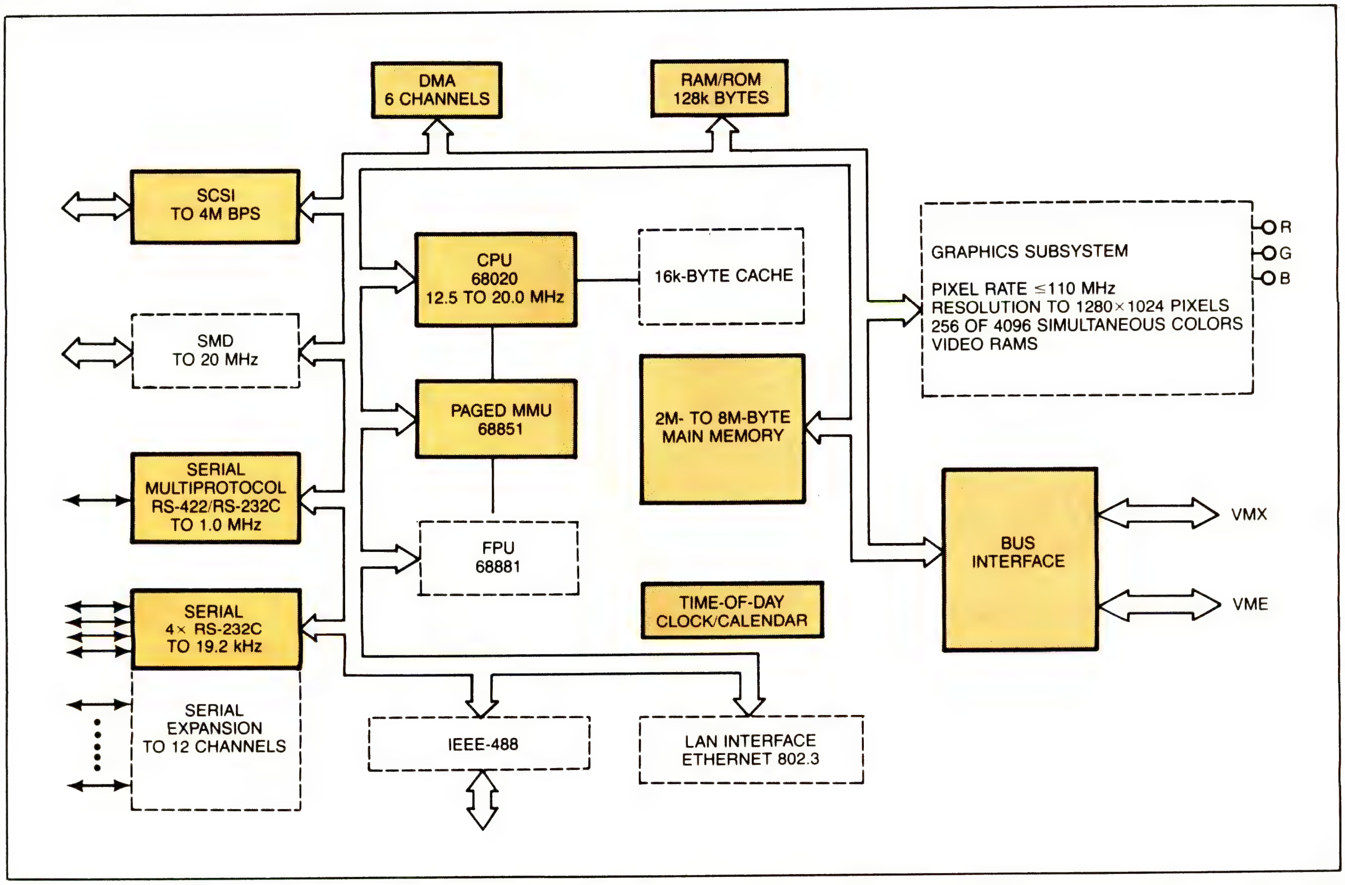
For connection to peripherals, the board has an SCSI X3T9.x interface that provides disk and tape information-transfer rates as high as 4M bytes/sec. An optional SMD interface can provide disk information-transfer rates to 15M bytes/sec.

You can specify between five and 17 serial ports for the Uni-System. The board comes with four 9.6k-baud RS-232C ports, as well as a 1M-baud port that can implement RS-422 or RS-232C protocols. The vendor can put as many as 12 additional 9.6k-baud RS-232C ports (for a total of 16) on the board. An IEEE-488 interface and Ethernet capability are optional.

The board's graphics option offers 640×480-pixel resolution in eight bit planes. The graphics circuit contains an HD63484 graphics processor and a video memory that's separate from the main memory. The board comes with software compilers and debuggers and can operate under either the Unix System V or the Berkeley Unix 4.2 operating systems. The compilers and debuggers help you write programs in C, Pascal, and Fortran 77. The standard board costs $6000 in OEM quantities.—***David Smith***

Goodspeed Systems Inc, Box 29, East Haddam, CT 06423. Phone (203) 873-1481.

Circle No 728



***Capable of combining networking and graphics** with I/O, memory, and processing hardware, the Uni-System can provide a complete 32-bit computer on a triple-height VME Bus board.*

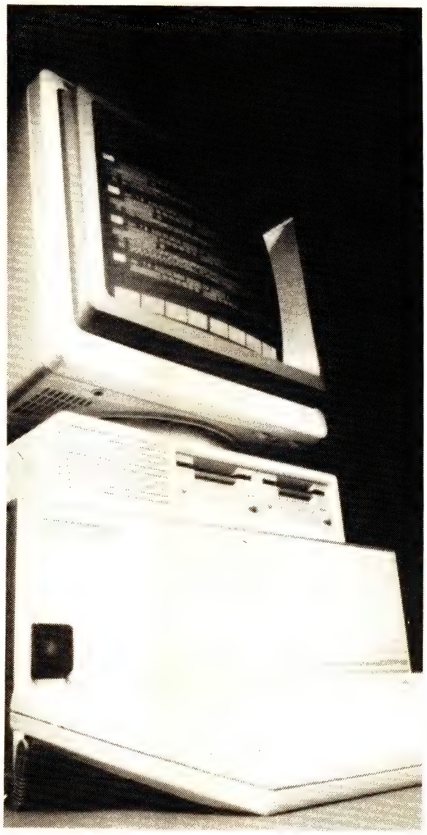
Programmable 802.3 LAN-protocol analyzer traps message frames in 1M-byte buffer

The HP4971S LAN-protocol analyzer lets you test your own IEEE 802.3 or Ethernet baseband 10M-bps LAN. Using the analyzer, you can monitor and capture message frames in a 1M-byte buffer. The analyzer uses 16 user-definable filters for packet-trapping criteria and message-transmission triggers.

You can display the captured frames in hexadecimal, ASCII, or EBCDIC, or in combinations of these three formats. Using a soft-key-based programming language, you can configure the analyzer to selectively store message frames from the network, to transmit as many as 16 predefined messages when it receives an appropriate trigger, and to measure network performance by using event timers and counters.

In its simplest mode, the 4971S stores every message frame appearing on the attached network. Each frame is time-stamped with a resolution of 32 µsec, so you can measure network-traffic speed and node-response times. You can scroll through each captured packet and mark those of interest for comparison or further examination. You can display node addresses in hexadecimal notation, or, for a more understandable data display, you can assign alphanumeric names to 500 network nodes.

For troubleshooting specific network problems, the analyzer offers focused message capture: You can use the 16 programmable filters to designate which frames to store. Filtering criteria (which include source address, destination address, and type field) use 14 hardware-trigger bytes. You can also specify maximum and minimum frame length, a feature that's useful when you're searching for partial frames or jabber problems.



Offering soft-key programmability, *16 user-definable filters, event timers and counters, and triggered message generation, the 4971S LAN protocol analyzer lets you troubleshoot IEEE 802.3 and Ethernet LANs and measure their performance.*

An additional 47 hardware-trigger bytes are available for use within the data field of the message frame. Filters share hardware-trigger bytes. For example, if you use a trigger byte to monitor the seventh byte in the data field, some or all of the filters can use only one trigger byte to monitor that byte position, even though each of the filters may be set to look for a different value in that position.

A soft-key-based programming language allows you to use the filters sequentially and in combination to further qualify frames for capture. You can program the capture to start or stop when a filter is matched, so you can see the events that lead to or follow the point of interest. The frame that matches a filter can also be positioned in the center of the buffer. You can use the filters to mark frames of interest for subsequent examination.

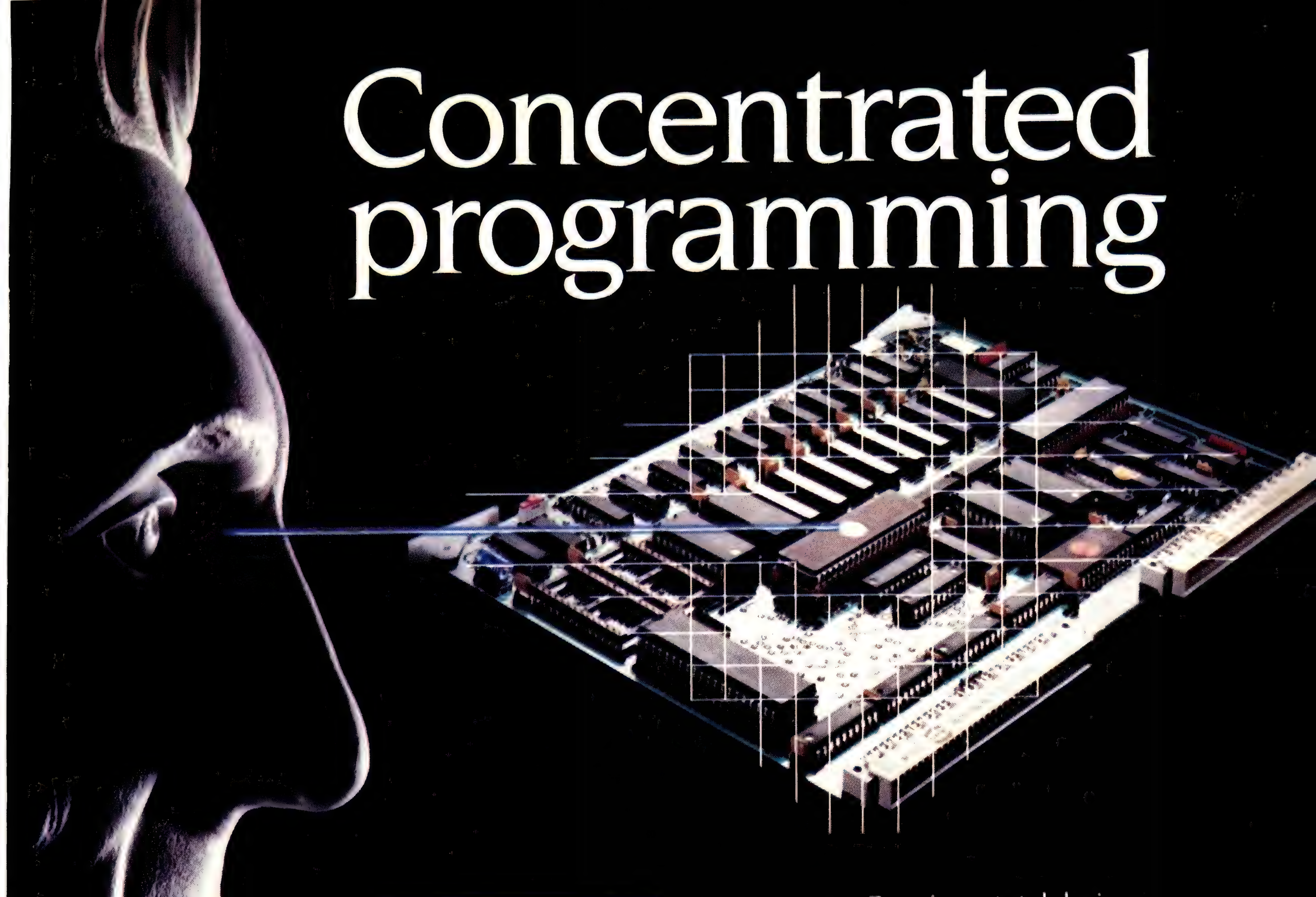
The 4971S also allows complex multiway branching, in which decisions are based on network events and the passage of time between events.

The 4971S supports 16 message-transmission buffers. A message can be transmitted in respose to an incoming frame within 10 msec typ. You can define messages that range from 5 to 2026 bytes in length. These limits are beyond the legal limits (1518 bytes max) of Ethernet frames, so you can test a node's reaction to message fragments and jabber problems. The 4971S can load the network by as much as 90% of its capacity. By varying the load the 4971S generates, you can test a network's sensitivity to loading.

With a keyboard, CRT display, dual floppy-disk drive, media-access unit, and cables, the 4971S costs $30,000. Delivery, eight weeks ARO.—***Steven H Leibson***

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 727



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CIRCLE NO 46

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HM 65770	4 K x 4	35/45
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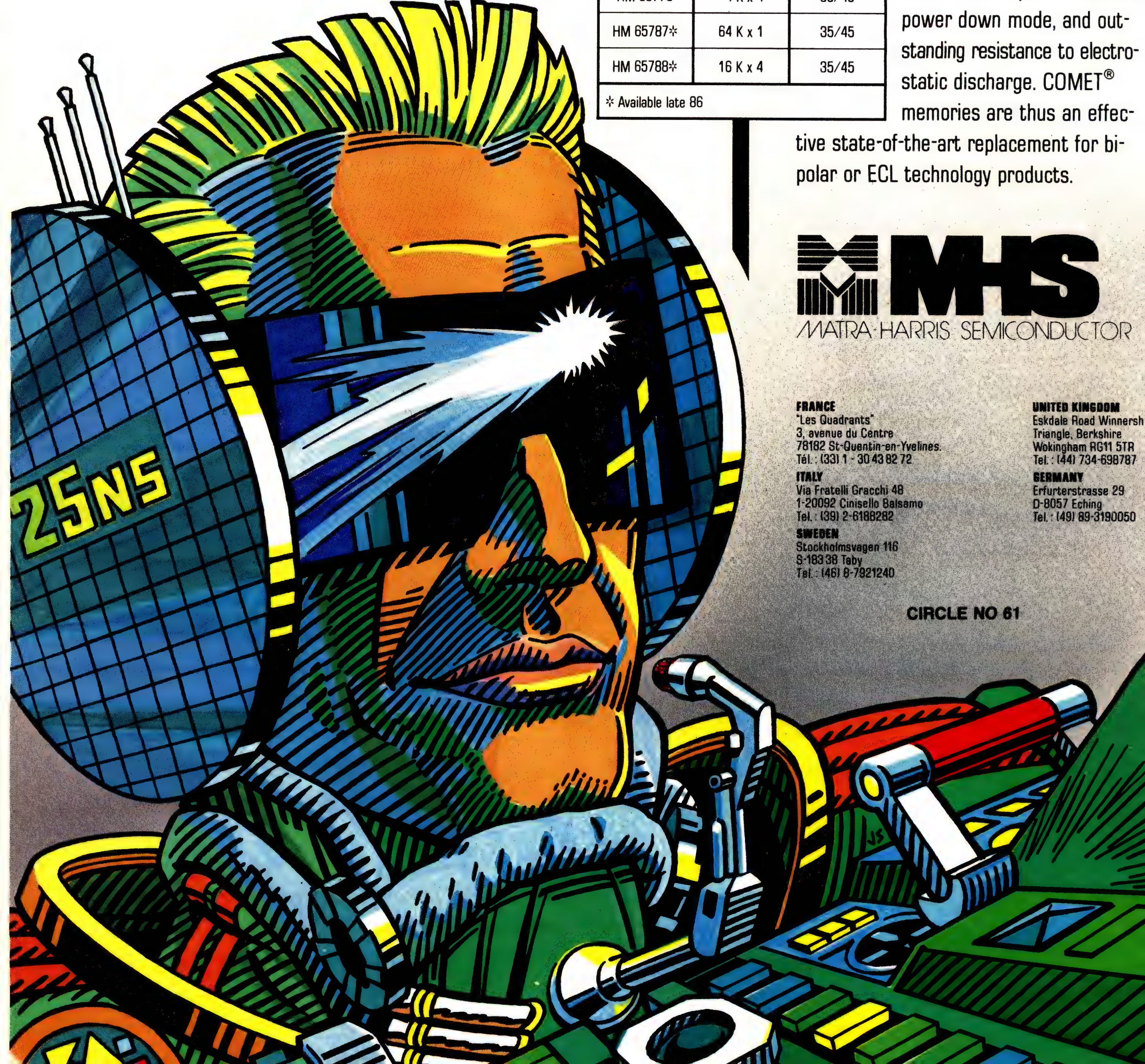
CIRCLE NO 61



Printed-circuit-board sockets simplify LED installation

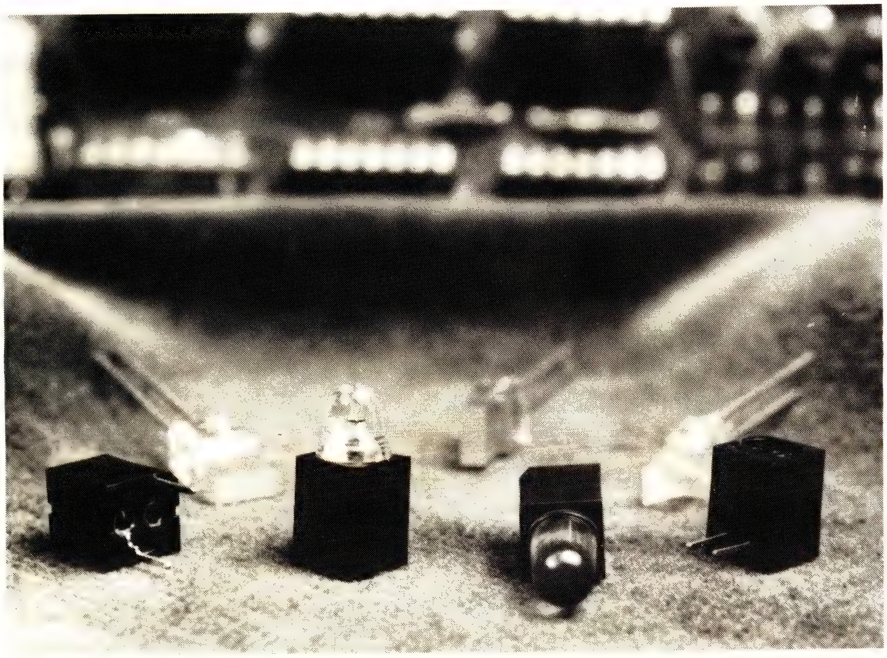
If you've ever needed to replace LEDs that have been soldered to a pc board, you know how difficult, time consuming, and costly the task can be. The PCH and PCV Series sockets provide an inexpensive solution to the problem: They offer a reliable means of electrically connecting LEDs to pc boards without soldering. The sockets accommodate both low-profile and standard-length LEDs. Because they're compatible with wave-soldering techniques, you can mount the sockets along with the other components and assemble the board in one step.

PCH devices accommodate horizontally mounting LEDs; PCV sockets handle LEDs that mount vertically. Both socket versions are molded from UL-listed nylon plastic and feature tin-plated phosphor-bronze contacts. You can insert and remove LEDs from either the front or the back of the sockets. The sockets' finger contacts automatically adjust to accommodate a variety of LED lead shapes and sizes. The LEDs must, however, have dual leads on 0.1-in. centers.

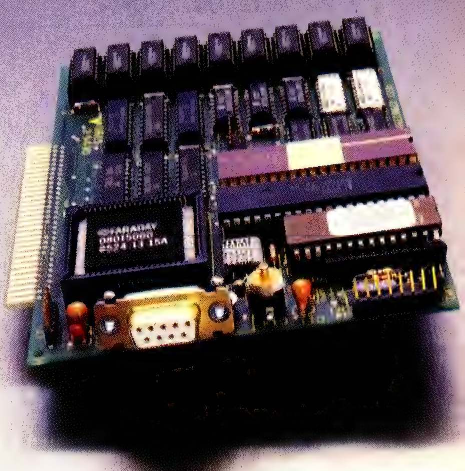
The sockets also feature polarity identification, standoffs, and lock-type vibration security. This security feature, which allows you to bend the LED leads after they've been inserted into the socket, makes the sockets suitable for use in high-vibration and high-shock applications. Further, the PCV sockets let you insert the LEDs through a hole in the back of the pc board, so they're suitable for use in applications involving dead-front-panel lighting, where space is usually limited. PCV and PCH Series sockets cost $0.25 (10,000).—***Tom Ormond***

Visual Communications Co, Box 986, El Segundo, CA 90245. Phone (213) 822-4727.

Circle No 732



Simplifying the installation and replacement of pc-board-mounted LEDs, *PCV and PCH Series sockets provide a reliable means of electrically connecting LEDs to circuit boards. The devices handle a variety of lead shapes and sizes and accommodate both standard-length and low-profile LEDs.*



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CIRCLE NO 63

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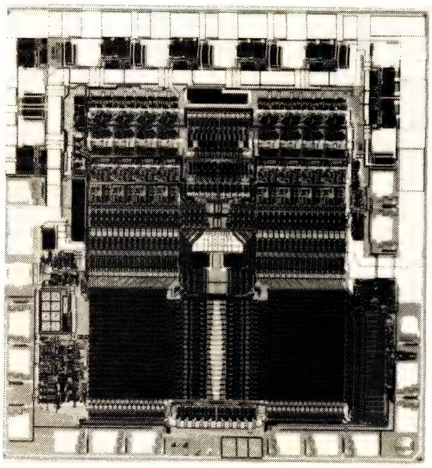
Electrically erasable array replaces 20- and 24-pin PLDs

The GAL 20V8 programmable logic device (PLD) can substitute for a variety of 24-pin PLDs, but it draws roughly half the current that the traditional PLDs use. Like its predecessor, the 20-pin GAL 16V8, the GAL 20V8 is electrically erasable and reprogrammable. You can program the parts on PLD programmers from Data I/O Corp (Redmond, WA) and Stag Microsystems Inc (Sunnyvale, CA). The GAL 20V8 has a 25-nsec propagation delay, which is equivalent to that of an A-Series bipolar PAL device, but it draws 90 mA max—half the PAL device's current-consumption spec. In addition, the GAL 20V8's outputs can sink 24 mA, as can many bipolar parts.



Although it offers the 25-nsec propagation delay *of an equivalent bipolar PLD, the electrically erasable GAL 20V8, a CMOS PLD, draws only half the current that the bipolar device draws.*

Both the GAL 16V8 and the GAL 20V8 have programmable macrocells that drive their outputs. The PLD programmers contain programming patterns that specify the macrocell configurations for emulating a particular type of device. The GAL 20V8 can replace such devices as the 14L8, 16L6, 18L4, 20L2, 20L8, 20R8, 20R6, and 20R4. You can implement registered devices like the 20R4 because the macrocells are programmed to implement a register at four of the GAL's outputs. Further, because you can program any of the macrocells to form a register, you have more flexibility in assigning output signals to particular pins than you do when you use a registered device.

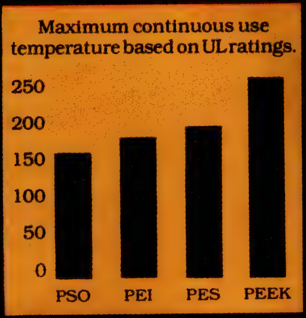
Because the GALs can be erased and reprogrammed, the manufacturer can test them before shipment and guarantee 100% functionality and 100% programming yield.

The GALs, which let you use standard PLD programming tools such as Abel, CUPL, and PALASM to create your design, can be programmed in two-thirds the time it takes to program PAL devices. The GAL 20V8 comes in a 300-mil plastic package. A 25-nsec version costs \$17.63, and a 35-nsec version costs \$13.26 (100).—***David Smith***

Lattice Semiconductor Corp, 15400 NW Greenbrier Parkway, Beaverton, OR 97006. Phone (503) 629-2131.

Circle No 730

The heat was on. And in test after grueling test for high-temperature performance, Victrex® resins beat the leading competition.



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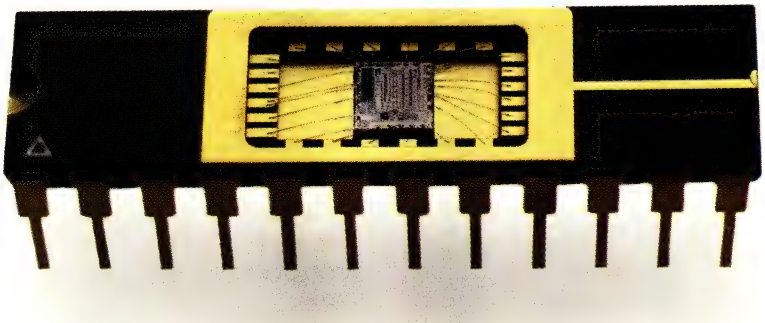

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ANALOG DEVICES

CIRCLE NO 66

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	18	27	55	0	0	11.3	7.8
Pot-Core	0	22	45	33	0	0	9.3	9.1
Laminate (power)	0	21	57	22	0	0	8.4	7.3
CONNECTORS								
Military panel	14	0	72	14	0	0	8.0	10.9
Flat/Cable	15	54	31	0	0	0	3.5	5.0
Multipin circular	11	22	45	22	0	0	7.6	10.6
PC	13	40	47	0	0	0	4.5	7.3
RF/Coaxial	0	40	60	0	0	0	5.6	8.0
Socket	25	44	31	0	0	0	3.4	4.5
Terminal blocks	14	52	33	0	0	0	3.7	4.7
Edge card	11	44	45	0	0	0	4.4	4.4
Subminiature	8	75	17	0	0	0	2.8	3.7
Rack & panel	0	40	60	0	0	0	5.6	6.7
Power	0	33	56	11	0	0	6.9	5.6
PRINTED CIRCUIT BOARDS								
Single-sided	0	65	35	0	0	0	4.1	4.0
Double-sided	0	50	50	0	0	0	5.0	4.3
Multilayer	0	10	60	30	0	0	9.8	6.2
Prototype	0	100	0	0	0	0	2.0	2.8
RESISTORS								
Carbon film	44	24	32	0	0	0	3.0	2.6
Carbon composition	26	26	37	11	0	0	5.2	3.5
Metal film	39	30	31	0	0	0	3.0	2.6
Metal oxide	33	27	40	0	0	0	3.7	3.6
Wirewound	14	36	50	0	0	0	4.7	4.9
Potentiometers	8	42	46	4	0	0	5.2	5.4
Networks	40	20	20	20	0	0	5.2	3.5
FUSES	35	45	20	0	0	0	2.5	1.6
SWITCHES								
Pushbutton	29	24	41	6	0	0	4.7	3.5
Rotary	7	22	57	14	0	0	7.3	5.2
Rocker	15	39	23	23	0	0	6.3	4.0
Thumbwheel	0	18	46	36	0	0	9.8	5.4
Snap action	22	45	11	22	0	0	5.3	4.5
Momentary	27	37	9	27	0	0	5.8	3.3
Dual in-line	20	40	20	20	0	0	5.6	5.1
WIRE AND CABLE								
Coaxial	44	28	22	6	0	0	3.2	1.7
Flat ribbon	53	37	10	0	0	0	1.6	1.4
Multiconductor	26	58	16	0	0	0	2.4	2.6
Hookup	42	50	8	0	0	0	1.7	1.1
Wire wrap	42	33	25	0	0	0	2.7	1.7
Power cords	27	53	13	7	0	0	3.2	2.5
Other	40	40	20	0	0	0	2.4	6.0
POWER SUPPLIES								
Switching	0	40	33	20	7	0	8.4	7.0
Linear	0	27	55	9	9	0	8.7	6.9
CIRCUIT BREAKERS	0	27	55	18	0	0	7.8	7.7
HEAT SINKS	19	25	44	12	0	0	6.0	4.2

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	25	30	35	10	0	0	5.0	3.4
PC board	7	33	33	27	0	0	7.6	4.4
Dry reed	0	33	67	0	0	0	6.0	6.3
Mercury	0	33	50	0	17	0	9.0	7.0
Solid state	8	34	25	25	8	0	8.8	6.8
DISCRETE SEMICONDUCTORS								
Diode	17	26	52	5	0	0	5.5	4.6
Zener	24	32	36	8	0	0	4.8	4.6
Thyristor	11	39	33	17	0	0	6.1	5.0
Small signal transistor	18	32	36	14	0	0	5.7	5.6
FET, MOS	0	0	55	36	9	0	12.6	8.4
Power, bipolar	14	29	29	21	7	0	8.1	7.2
INTEGRATED CIRCUITS, DIGITAL								
CMOS	19	24	33	19	5	0	7.4	6.7
TTL	18	24	23	29	6	0	9.0	7.2
LS	13	33	20	27	7	0	8.3	7.8
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	9	9	55	18	9	0	9.8	6.2
OP amplifier	13	25	37	19	6	0	8.1	7.9
Voltage regulator	24	23	29	18	6	0	7.2	6.9
MEMORY CIRCUITS								
RAM 16k	17	33	8	42	0	0	8.0	4.0
RAM 64k	17	42	16	25	0	0	6.2	3.0
RAM 256k	13	38	12	37	0	0	7.8	3.3
ROM/PROM	23	33	11	22	11	0	8.0	4.0
EPROM	17	50	8	17	8	0	6.5	5.2
EEPROM	14	43	0	29	14	0	9.1	6.2
DISPLAYS								
Panel meters	10	40	40	10	0	0	5.6	6.0
Fluorescent	0	25	75	0	0	0	6.5	8.0
Incandescent	0	40	60	0	0	0	5.6	5.7
LED	15	30	40	15	0	0	6.2	5.2
Liquid crystal	0	17	67	16	0	0	8.3	9.3
MICROPROCESSOR ICs								
8-bit	6	44	31	19	0	0	6.4	5.5
16-bit	0	12	38	50	0	0	11.3	7.2
FUNCTION PACKAGES								
Amplifier	18	18	55	9	0	0	6.2	6.3
Converter, analog to digital	0	40	40	20	0	0	7.2	9.1
Converter, digital to analog	0	30	40	30	0	0	8.6	8.5
LINE FILTERS	10	10	70	10	0	0	7.4	7.5
CAPACITORS								
Ceramic	28	36	32	4	0	0	3.9	4.2
Ceramic monolithic	17	44	33	6	0	0	4.4	3.7
Ceramic disc	18	47	29	6	0	0	4.2	5.1
Film	17	28	39	16	0	0	6.3	4.9
Electrolytic	23	27	32	18	0	0	6.0	4.6
Tantalum	9	35	43	13	0	0	6.2	6.9
INDUCTORS	9	46	36	9	0	0	5.3	5.0

Source: *Electronic Purchasing* magazine's survey of buyers

ABBOTT'S NEW TRIPLE-OUTPUT 100 kHz 200-WATT SWITCHING DC-DC CONVERTER.

When an application calls for a small yet powerful converter, Abbott delivers the juice. That's why Abbott has created the model BC200. With a 2.5 watt/cubic inch power density, it delivers a reliable 200 watts with low ripple/noise and EMI within the limits of MIL-STD-461B.

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MODEL BC200 SPECIFICATIONS

DIMENSIONS	**1.875" x 5.75" x 8"**
Input voltage	*22 to 32 V dc*
Outputs	*5 V, ±12 V; or 5 V, ±15 V*
Switching frequency	*100 kHz*
Efficiency	*60% minimum*
Ripple/noise	*100 mV peak-to-peak maximum*
Line regulation	*10 mV (22 to 32 V dc)*
Load regulation	*10 mV main (0.5% aux outputs)*
EMI	*Meets MIL-STD-461B*
Environment	*MIL-STD-810C, MIL-S-901C*
Input protection	*MIL-STD-704D*
Operating temperature range	*−55°C to +100°C*
Storage temperature range	*−65°C to +125°C*
MTBF (Ground benign)*	
Standard	*140,000 hours*
ER option	*1,100,000 hours*
MTBF (Air inhabited)*	
Standard	*23,000 hours*
ER option	*160,000 hours*

**MIL-STD-217D (50°C Baseplate)*

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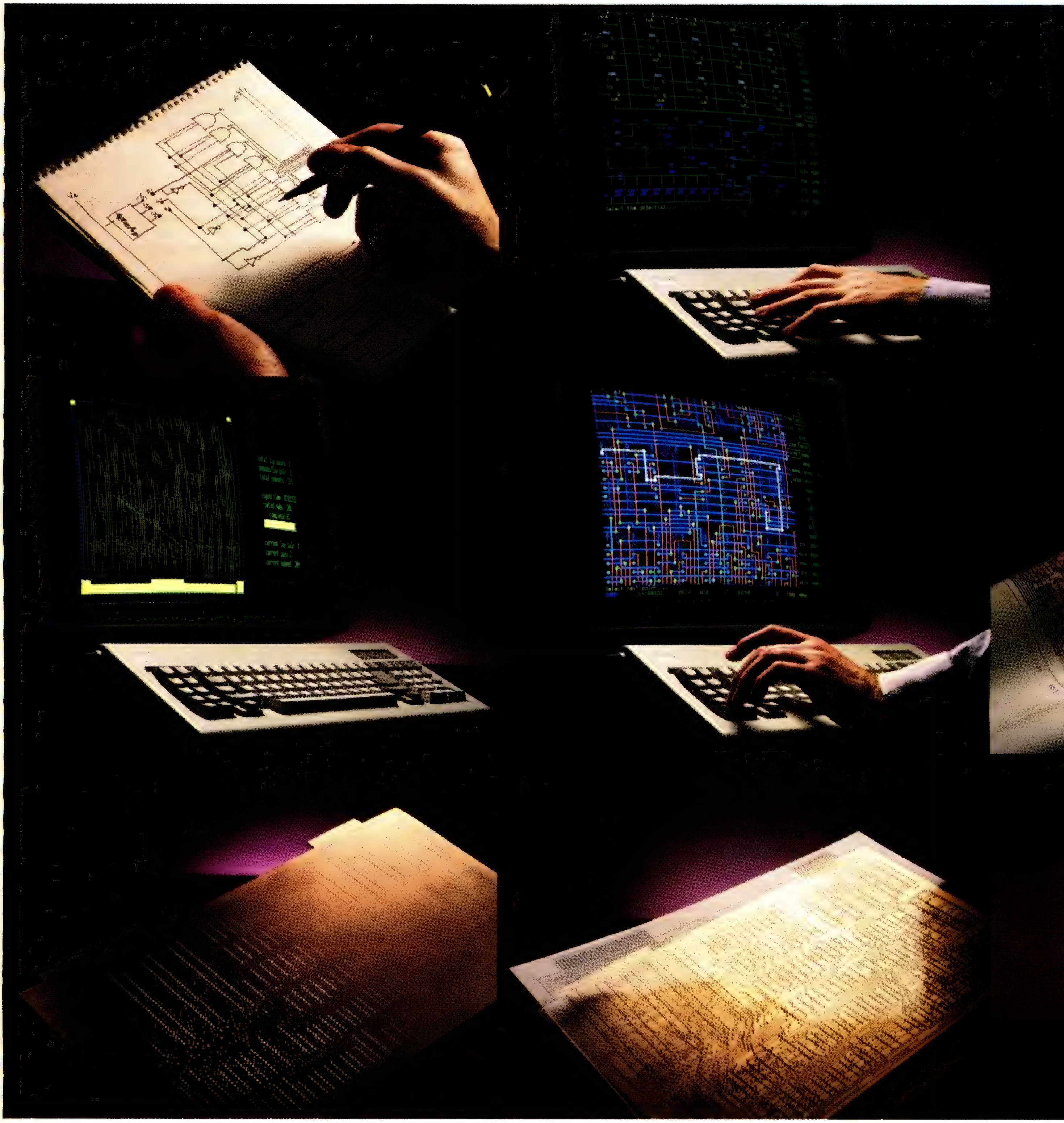
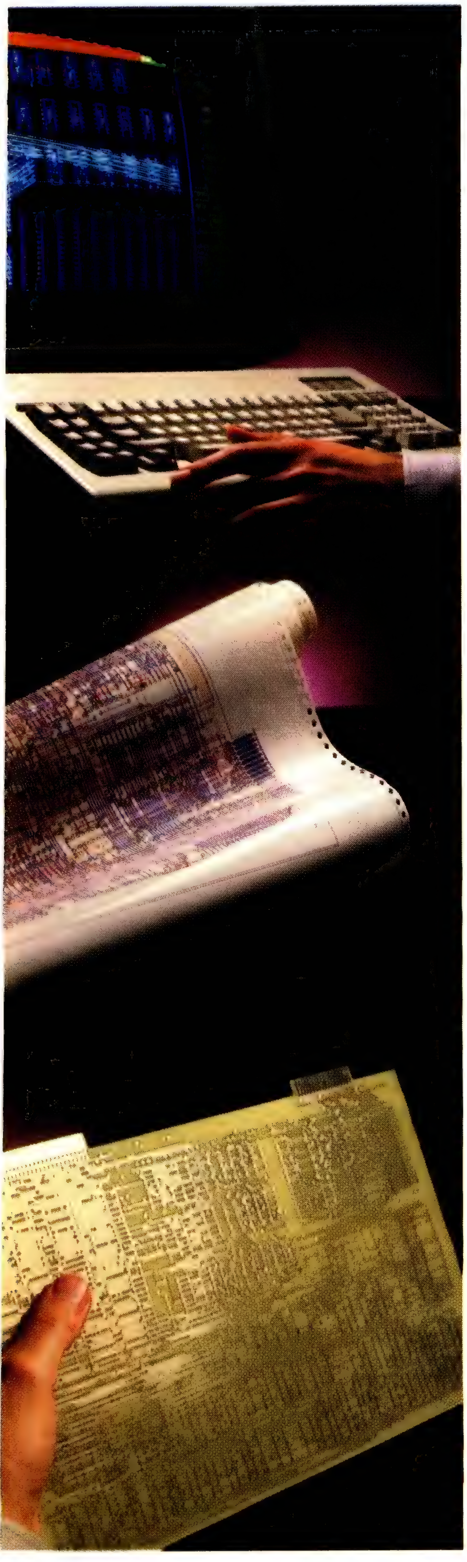


P-CAD's newest generation CAE/CAD design tools can take you all the way from concept to finished design on one system. That's why it's the Benchmark against which other design automation products are being judged.



☐ First, Compare Function.

P-CAD provides a true end-to-end PCB design solution. Designers can create preliminary sketches interactively with the PC-CAPS schematic capture program. Once the conceptual data is formalized, tools like PC-PLACE perform automatic component placement. A built-in histogram capability aids in part swapping to optimize placement. Next, PC-ROUTE provides automatic routing for trace interconnections.

After the plots have been run and artwork generated, PC-DRILL extracts the data needed to generate paper tapes. These tapes drive the NC-drilling machines so that prototypes and finished PC boards can be manufactured. With P-CAD, concept to prototype is all a single, totally integrated system.

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Other CAE/CAD systems give you some of P-CAD's features. But no one has them all. Here are a few of the capabilities that make P-CAD the Benchmark in PCB design:

- All software runs under MS-DOS™
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- Boards can be designed on up to 25 layer pairs with PC-ROUTE.
- PC-ROUTE users can select from multiple routing strategies for the highest completion rates.
- User can stop and start PC-ROUTE at any time.
- PC-PLACE lets user define multiple placement lattices, provides tools for locating, analyzing, and optimizing the resulting placement, and handles both DIPs and discrete components.
- PC-DRILL can extract data from PC-CARDS design database for transferring data to paper tape punch machines, and provides optimization of drilling patterns.
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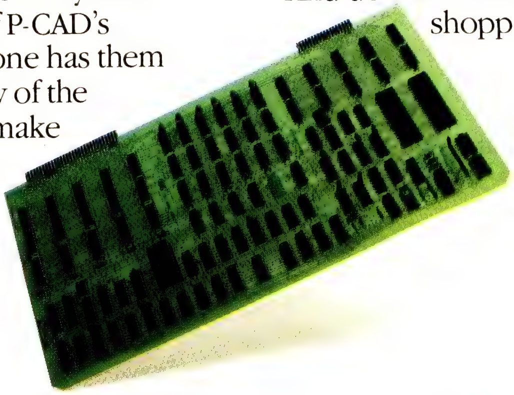
And do a little comparison shopping.



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CIRCLE NO 68

For the Technical Professional:

The story behind IBM's new 32-bit RISC PCs.

These aren't your ordinary workstations.

For IBM RT Personal Computers—6150 and 6151—are built around a revolutionary 32-bit, virtual memory, RISC-based microprocessor. Developed and manufactured by IBM.

The significance? Far faster throughput. Because RISC (for Reduced Instruction Set Computer) architecture eliminates many of the unnecessary bells and whistles found in conventional chip design.

What's more, an IBM RT PC can directly address up to four megabytes (Mb) of real memory, over a trillion bytes of virtual memory and up to 210 Mb of DASD, or disk storage.

All of which makes IBM RT PC microprocessors particularly well suited for the total application requirements of technical professionals working in engineering, scientific, industrial and academic environments.

The IBM RT PC 6150 Model 20
Floor-standing unit

CADAM® and CIEDS[1] Software

One of the key programs available for the IBM RT PC—attached to the IBM 5080 Graphics System—is Professional CADAM. And it's compatible with established host-based CADAM.

There's also Computer-Integrated Electrical Design Series (CIEDS), which allows for the schematic capture of integrated circuit designs.

And there is a growing list of applications available from software companies in the following fields: mechanical and electrical CAD/CAM, petroleum production, artificial intelligence, software engineering, project management and graphics.

UNIX[2] System V

The primary operating system is derived from the UNIX System V—with some very important enhancements added by IBM. These enhancements make this operating system—Advanced Interactive Executive or AIX[3]—much easier to use, give it improved performance and reliability, and also add a virtual storage capability.

This operating system gives you multi-user and multi-tasking operations for up to eight concurrent local or remote users working on low-cost ASCII terminals such as the IBM 3161.

There is also a full-function IBM SQL/RT relational data base management facility available.

Understands Many Languages

The IBM RT PCs are highly literate. You'll be able to write and run applications in C, Fortran 77, BASIC, PASCAL and Assembler.

And as for general-purpose applications, you'll be able to run UNIRAS[4] (for engineering and business graphics), RS/1[5] (for data analysis and graphing functions), IMSL[6] (a library of Fortran subroutines), Interleaf's Workstation Publishing Software[7] Solomon III[8] (for accounting), SAMNA+[9] (for spreadsheet and word processing) and Applix IA[10] (for integrated office functions).

PC Compatible

The IBM RT PCs can incorporate as an optional feature an Intel 80286 coprocessor (in effect a PC AT on-a-board) that runs concurrently with the 32-bit RISC processor. That means the RT PCs can support many existing IBM PC applications and the interchange of their related data. It also means the RT PC I/O bus can accept standard PC cards.

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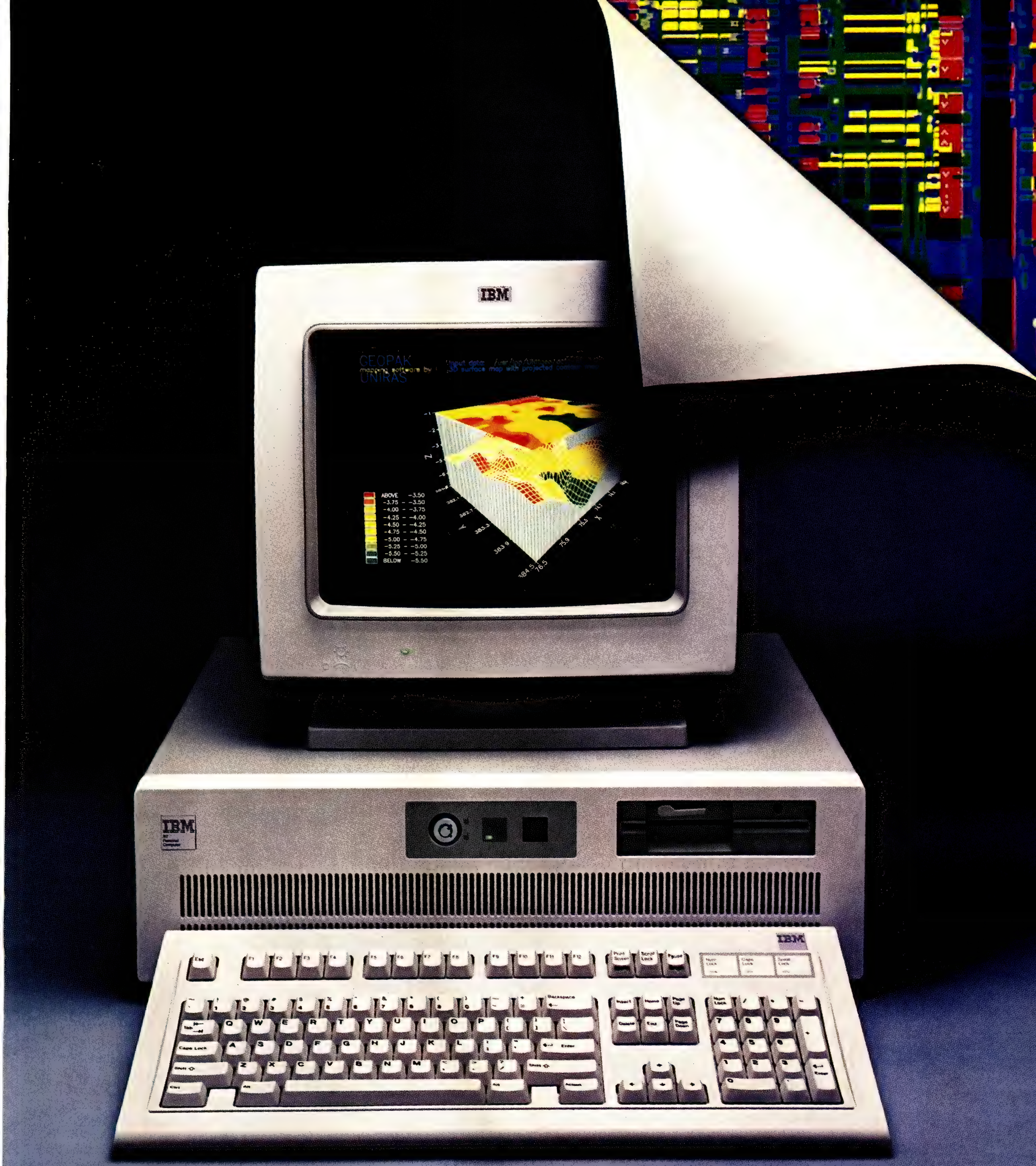

The IBM RT PC 6151 Model 10
Desk-top unit

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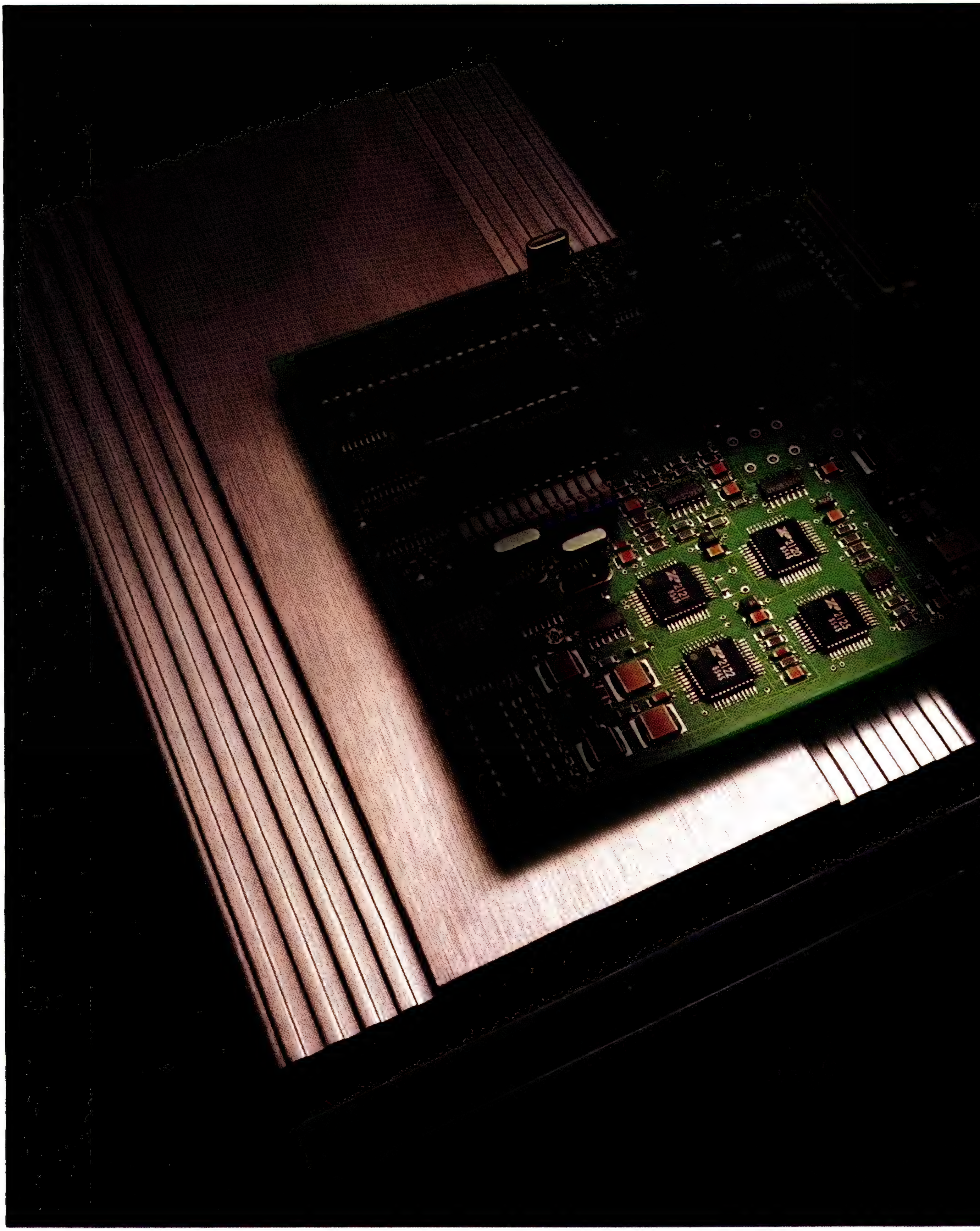
EXAR offers performance and



compatibility in 212A modems

Superior Performance Under All Conditions

With AT&T divesture, the likelihood of getting worst case line conditions has increased considerably. At EXAR we feel that modems must operate reliably under all the harsh conditions of the telephone network. These conditions include:

- ■ Worst Case Line Conditions (3002, C0)
- ■ Low Carrier Levels (−40 dBm)
- ■ Varying Line Impedance (150 Ω)
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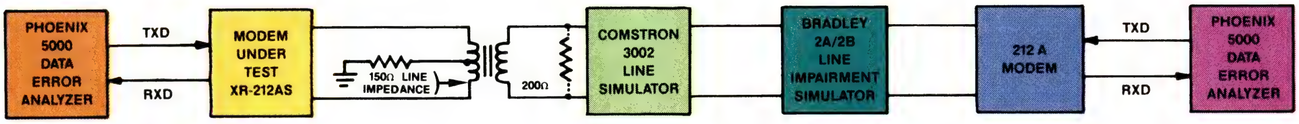

PHOENIX 5000 DATA ERROR ANALYZER
TXD
RXD
MODEM UNDER TEST XR-212AS
150Ω LINE IMPEDANCE
200Ω
COMSTRON 3002 LINE SIMULATOR
BRADLEY 2A/2B LINE IMPAIRMENT SIMULATOR
212 A MODEM
TXD
RXD
PHOENIX 5000 DATA ERROR ANALYZER

EXAR Performs Where Competition Fails

The XR-212AS performance under these worst case line conditions is excellent. Our modem experts could not even make the competitor's chips work under these conditions. Our lab test results show:

EXAR		COMPETITION
S/N = 12 dB	BER = 1/10 −5	Non-functional

Would you want your customers to keep dialing over and over to get optimum line conditions? Don't take the chance! EXAR's chip set outperforms the competition under all conditions.

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Device	Function	Application
XR-2121	212A modulator	Modem Signal Processor
XR-2122	212A demodulator	
XR-2125	212A data buffer	
XR-2129	212A/V.22 filter	
XR-2120	212A filter	Modem filtering
XR-2126	212A/V.22 filter	
XR-2127	212A/V.22 filter	
XR-2128	212A/V.22 filter	

EXAR also supplies support circuits such as op amps, line drivers and receivers in a wide variety of packages including surface mount.

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CIRCLE NO 70

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Datacomm protocol ICs

Multiprotocol ICs can support communcations for synchronous, full-duplex packet-switching networks. They also support the still-popular asynchronous character-switching protocols employed, for example, in RS-232C links. Many of these chips furnish programmable options that give you increased software control over protocol selection.

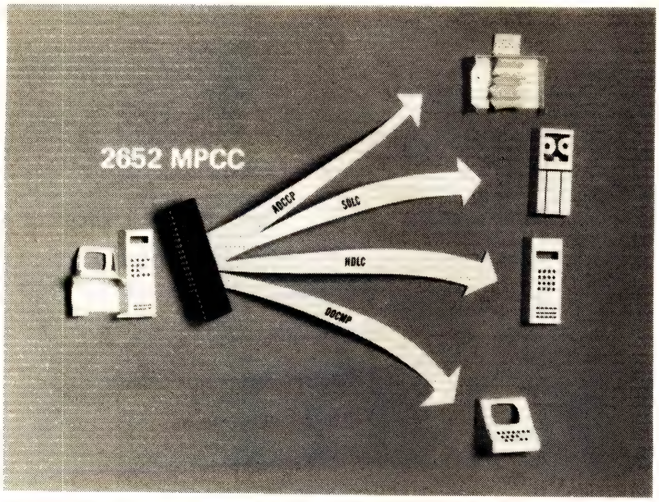
Denny Cormier, *Western Editor*

Manufacturers of communications ICs are offering a plethora of protocol ICs, ranging from standard UARTs to programmable multiprotocol chips that you can tailor to your needs. Intel, Signetics, and Standard Microsystems, for example, are introducing programmable multiprotocol ICs to support not only your asynchronous character-switching datacomm links but also a variety of synchronous packet-switching network protocols, including IBM's SDLC and the CCITT's X.25. These chips manage error-correction and data-encryption at the hardware level, but programmability is the real attraction. What's more, if you are working on a multichannel proprietary datacomm link, for either personal-computer peripherals or mainframe workstations, you can now put a new breed of multiprotocol ASICs from Cirrus Logic to work in your design.

***Datacomm protocol ICs tie your computer system** to a wide variety of data-processing resources. Your protocol needs may run to new CMOS versions of the familiar UART or to the programmability of flexible multiprotocol ICs. (Photo courtesy Harris Corp)*

Because a wide variety of computer peripherals and mainframe timesharing networks are designed for asynchronous communications through RS-232C or -485 interfaces, Gould/AMI, Harris Corp, Rockwell International, Standard Microsystems, Western Digital, and others are introducing programmable CMOS ICs to reduce power consumption while providing more flexible control over data-rate selection, framing, bus contention, and connection to telecommunications equipment. At the same time, CMOS versions of standard asynchronous datacomm ICs, like asynchronous communications interface adapters (ACIAs), are making their debut.

In general, the selection of the appropriate protocol ICs to manage parallel-to-serial data conversions depends upon the following factors: channel bandwidth, the number of terminals to be managed by the network



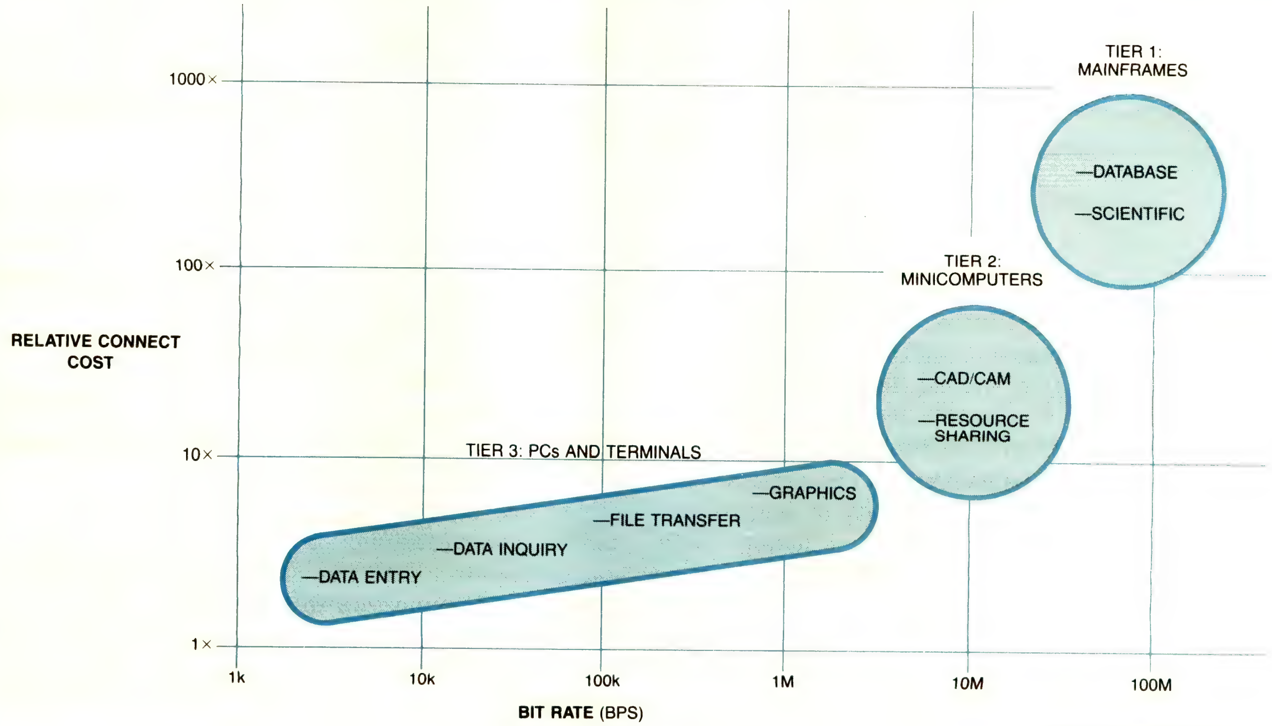
For mainframe and PC datacomm links, *the NMOS SCN2652/68652 multiprotocol communications controller from Signetics handles both bit-oriented (SDLC, HDLC, ADCCP) and byte-control protocols (DDCMP and bisync) with either CRC or VRC error control.*

or system, DTE memory and access methods, acceptable protocols, and overall reliability of the datacomm system. The cost of the chip that you pick will usually rise proportionally with the cost of the whole system.

Fig 1 groups datacomm systems within engineering and office environments into the three basic applications tiers—mainframes, minicomputers, and PCs—which include such specific applications as CAE resource sharing, credit checking, electronic fund and mail transfers, inventory control, hospital and medical information retrieval, point-of-sale data collection, and automatic teller machines (ATMs). As you go up the scale in **Fig 1,** your need for the multiprotocol chips will tend to increase. At the low end, for example, if you're designing a communications port for a low-cost ASCII terminal, you might be best off with a conventional UART or USART.

At the other end of the scale, in the mainframe tier, programmable multiprotocol chips are likely to prove more useful. Character-oriented protocols once prevailed in mainframe applications, but standard packet-switching dialogues are increasingly popular because they consume less overhead than asynchronous protocols, which require start- and stop-bit framing. As designers of software for mainframes mount a concerted effort to bring datacomm interfacing protocols under software control, they're using the multiprotocol chips to add the internationally accepted synchronous X.25 protocol to their systems, which might already include asynchronous character switching as well as synchronous protocols like XDLC.

An example of this effort was presented last January



(SOURCE: INTEL CORP)

Fig 1—Your selection of ICs to handle network protocols *must take into account relative component costs as a function of the data-transfer bandwidths you plan to attain.*

CMOS versions of standard asynchronous datacomm ICs, like asynchronous communications interface adapters (ACIAs), are making their debut.

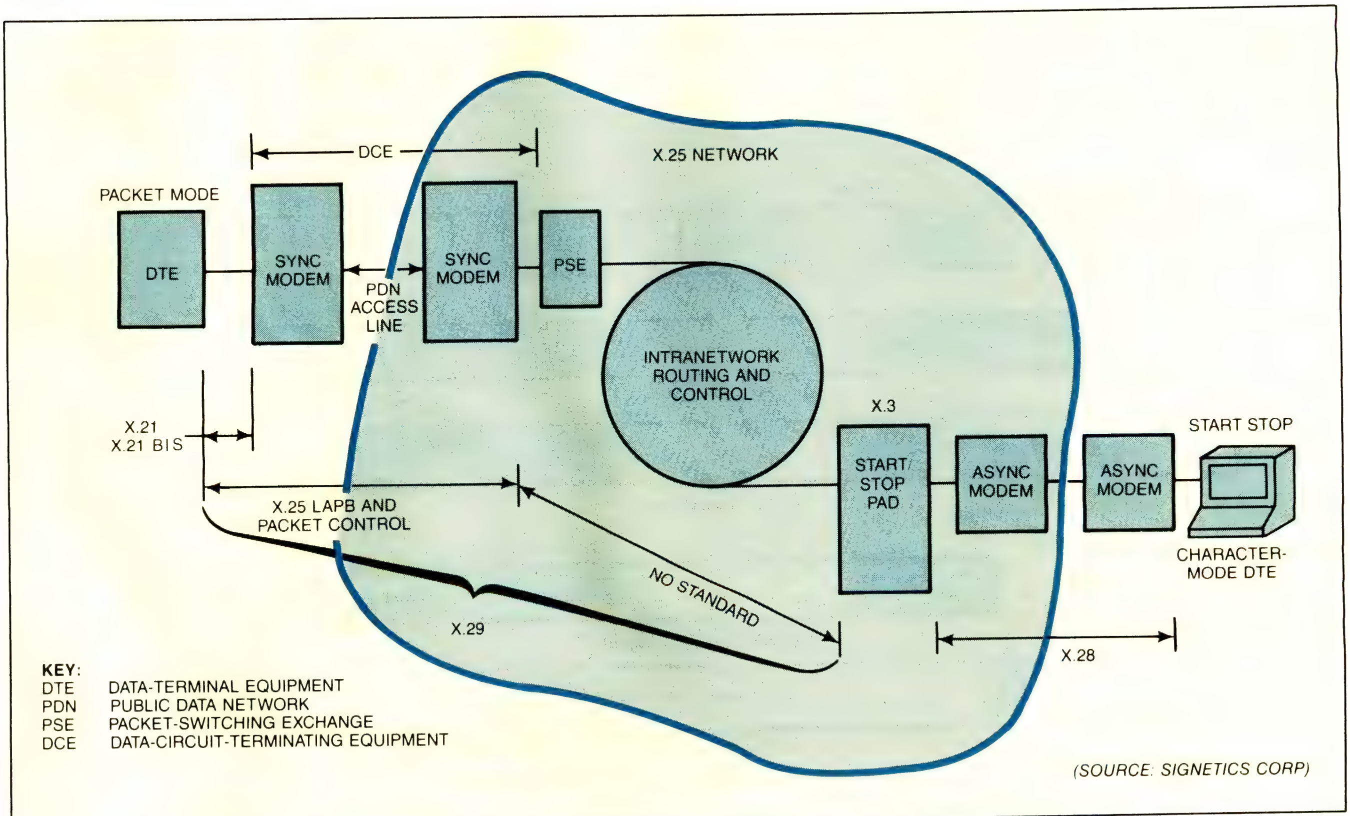
at the 1986 Denver Usenix Conference by Don Sterk, a UTS (Universal Time-Sharing) systems programmer at Amdahl Corp (Sunnyvale, CA), in his paper concerning full-duplex I/O support on mainframe computers **(Ref 1).** According to Sterk, the interfacing of character-switching UTS port drivers with X.25 protocols can enhance both user and system transparency of Unix I/O ports. Such an approach allows mainframe systems designers to port Unix through pre-existing X.25 datacomm hardware channels. Sterk designed such a system, which employed an Amdahl 4705 as a packetizing front-end processor that worked with an Amdahl 470 or 580 mainframe.

Keep in mind that the **Fig 1** scale doesn't always apply. You needn't be near the top of the scale to find that a multiprotocol chip is called for. For example, if you're linking a PC to an X.25 network **(Fig 2),** you will benefit from a multiprotocol chip. And when error-checking or datacomm security is an issue (see **box,** "Keeping your datacomm dialogue secret"), you'll definitely want to consider one of the latest generation multiprotocol ICs for your design.

One recently introduced multiprotocol IC is Intel's $8.95 (1000) 82530 serial communications controller (SCC). You can program it to support a variety of packet-switching synchronous protocols as well as character-oriented async protocols **(Fig 3).** The CMOS device (HMOS II) features dual full-duplex serial channels, an on-chip crystal, an internal baud-rate generator, an independent digital phase-locked loop for each channel, diagnostic local loop-back capability, and CRC-16 error-checking. The SCC handles synchronous datacomm links under interrupt-driven or DMA control when used in conjunction with Intel's MCS51 microcontrollers or with its iAPX86/88/186 μPs.

Intel's $8.30 (1000) 8274 multiprotocol serial controller (MPSC) is an HMOS, single-channel version of the 82530. When you provide μP support, the MPSC not only handles most error-checking bit/byte-synchronous protocols, but also lower-level X.25 packet-switching protocols at data rates as high as 880k baud.

Data sheets for both the SCC and the MPSC claim



(SOURCE: SIGNETICS CORP)

Fig 2—Although X.25 does not specify protocols *for intranetwork routing and control, it does cover physical data links to DCEs and DTEs as well as datacomm protocols within the network itself. Outside the X.25 domain, conventional protocols like the asynchronous X.28 and synchronous X.21 bis dominate.*

Character-oriented protocols once prevailed in mainframe applications, but standard packet-switching dialogues are increasingly popular.

X.25 compatibility. Mark Peterson, Intel's datacomm product marketing manager, elaborates on that claim by saying that both devices have an 8-bit bus structure and require support from an external μP to handle the 16-bit X.25 LAPB and LAPD protocols. Both chips come in 40-pin DIPs. NEC is a second source for the 8274 with its μPD7201A MPSC.

Expanding to meet multiprotocol needs

Signetics, with help from Motorola, has expanded its product line of datacomm-peripheral chips into a family of multiprotocol ICs. Signetics (an early developer of datacomm protocol ICs under the direction of Alan Weissberger, who also was instrumental in the formulation of the X.25 protocol standards) introduced the most powerful member of the family late last year. That chip, the MOS-LSI SCN68562 dual universal synchronous communications controller (DUSCC), offers several software-selectable protocols that range from bit-oriented XDLC or X.25 to byte-controlled bisync (X.21). Motorola's 68000 family μP can communicate with the DUSCC via asynchronous bus-control signals, and the DUSCC also handles interrupt-driven and DMA data transfers.

The SCN68562 controls each data-formatting channel via a separate 16-bit multifunction counter/timer, a digital phase-locked loop, and a CRC generator for error checking. You can use the IC's on-chip FIFO memory to reduce DMA overhead and the number of interrupts. Signetics offers the SCN68562 in either a 48-pin DIP or PLCC for $18 (1000). Hitachi plans to become a second source for the DUSCC chip in the third quarter.

Chip for high-speed telecomm

Signetics has another peripheral IC—the SCN2652/68652 multiprotocol communications controller (MPCC)—that's adaptable to X.25 protocol interface formats within either the mainframe or the PC datacomm applications tier. Although the MPCC is an NMOS device, it's TTL compatible and operates from a single 5V supply. The chip's ability to manage 8- or 16-bit protocol formats through a 3-state bidirectional data bus simplifies line-controller and front-end communications. For high-speed synchronous data transfers, like those in telecommunications DCE interfaces or industrial systems where noise interference is a problem, you can use the MPCC in conjunction with the

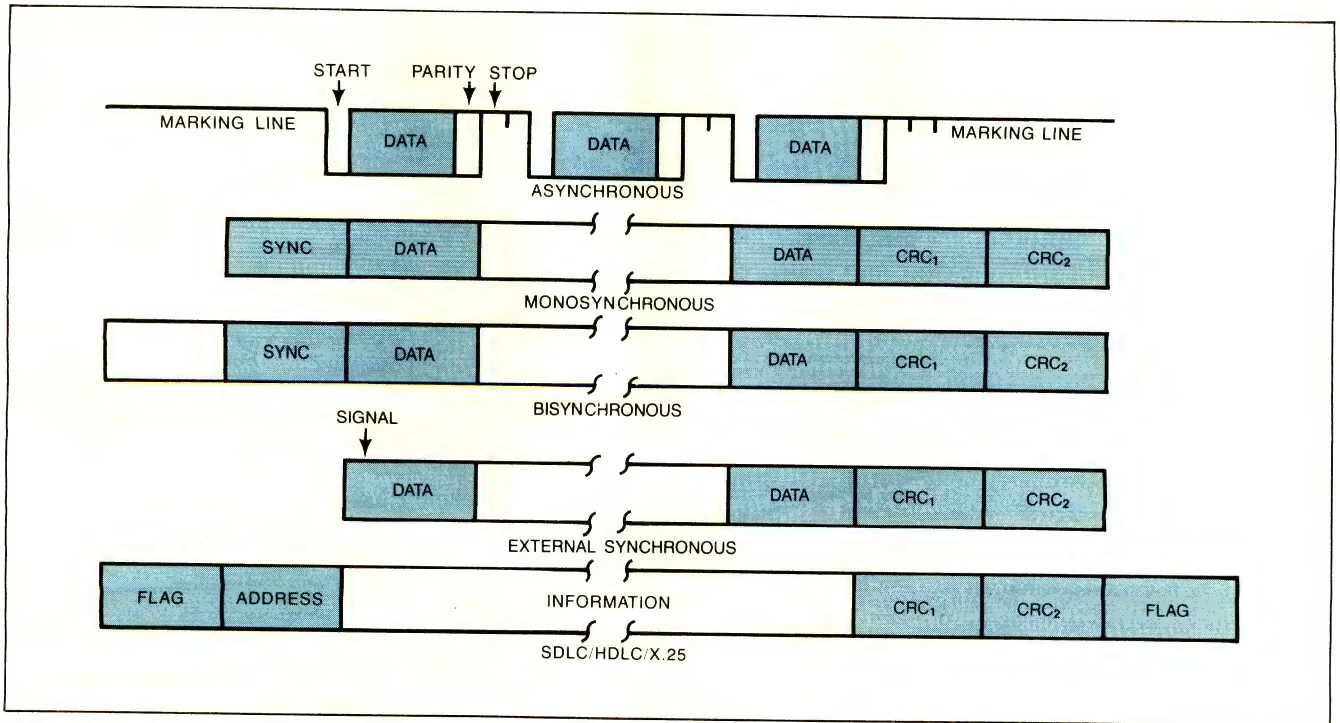


Fig 3—Many multiprotocol ICs handle both synchronous and asynchronous datacomm formats. *Intel's 82530 SCC uses the formats shown here. The reduced overhead and internal CRC error-detection algorithms of synchronous protocols (bisync, XDLC, X.25, etc) lead designers to prefer such protocols for high-speed data transfers.*

SCN2653/68653 polynomial generator checker (PGC) to handle CRC-12 and -16 error-checking protocols (**Fig 4**). The 2-MHz device is available in either a 40-pin DIP or PLCC and costs $4 (1000).

You can obtain from several other chip makers MPCCs that are functionally similar to the SCN2652. Last year, Rockwell International introduced its 4-MHz R68560/1 MPCCs, which support a variety of synchronous protocols in addition to X.25. The 48-pin R68561 supports word-length (16-bit) operations when connected to a 68000 bus, and the 40-pin R68560 manages byte-length (8-bit) operations from a 68008 bus. Unlike the Signetics MPCC, the R68560/1 parts provide an internal CRC algorithm. The R68560 and the R68561 sell for $18.50 and $20.90 (1000), respectively.

Other multiprotocol chips come from Standard Microsystems, Western Digital, and Zilog. Working at data-transfer rates as high as 1.5M baud, Standard Microsystems' COM-5025 multiprotocol universal synchronous receiver/transmitter (USYNRT) handles a

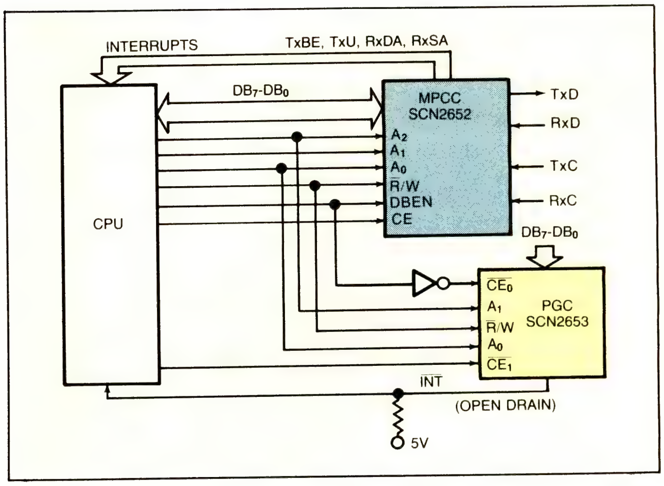


*Fig 4—**You can interface most of the standard synchronous datacomm protocols** with general-purpose 8-bit µPs at 2M-bps data rates through the Signetics SCN2652/2653 multiprotocol communications controller (MPCC). In this configuration, you can easily add an SCN2653/68653 polynomial-generator/checker chip to handle CRC-12 and LRC-8 error-detection at the hardware level.*

Keeping your datacomm dialogue secret

Last September, the National Security Agency (NSA) agreed not only to be responsible for the security of data communications for the Department of Defense, but also for datacomm links of all other federal agencies as well. Along with this initiative, the NSA plans to help members of the private sector, including the semiconductor industry, protect those datacomm links that involve unclassified national-security-related (UNSR) information from both political and industrial espionage.

Since the 1970s, most coded data exchanges have used the Data Encryption Standard (DES), developed jointly by IBM and the National Bureau of Standards. Instead of expanding upon the DES, the NSA, in its Directive #145, plans to supersede DES protocols with a new standard that incorporates specialized key-variable code-generating algorithms. The aim of these algorithms is to create nearly tamper-proof datacomm ICs. A restricted number of selected chip manufacturers will be given access to the coded algorithms.

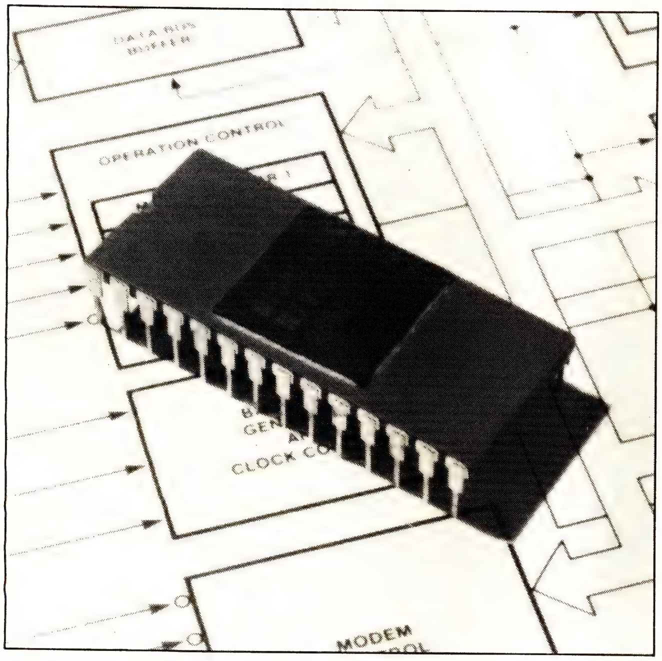
Chip for proposed code

Harris Corp has created the first commercially available chip, the CMOS HS3447 Cypher-I data-encryption device (DED) that converts parallel data to an encrypted serial stream and vice versa in accordance with NSA encryption protocols. Operating at data rates as high as 20M bps, the Harris DED chip runs considerably faster than standard DES ICs, like AT&T's T7000 data-encryption processor, which generates encoded characters at a maximum throughput rate of 4.7M bps.

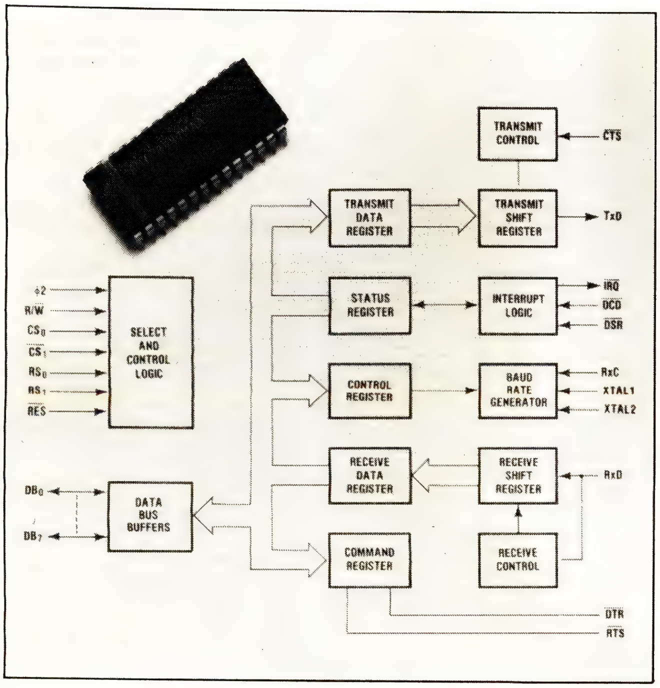
The HS3447 encrypts plaintext messages using NSA's key-variable protocol. For enhanced security, the key variable stored on chip is not externally accessible. The DED also handles deciphering of the coded text. The HS3447 comes in a 16-pin DIP and operates from a single 5V supply over the −55 to +125°C military temperature range.

Harris will not ship this part until you receive NSA approval for your project. When you get approval, Harris will ship parts within six to eight weeks. Pricing for the HS3447 military version is $215; for the commercial version, $163 (50). Larger OEM-quantity pricing is available upon request.

Even if you're only concerned with communications at the personal-computer level, you may find that an advanced multiprotocol chip is called for.



Offering either asynchronous or synchronous interfacing *to a variety of systems, the 8-bit SCN2661/68661 enhanced programmable communications interface from Signetics features 16 internal bit rates and short-circuit protection for Rx and Tx pins.*



Word lengths, stop bits, parity detection, interrupts, and 15 baud rates*—these are some of the programmable elements of Gould/AMI's CMOS S65C51 asynchronous communications interface adapter. The part is interchangeable with Mitel's MD-65C51 and Rockwell's R65C51 ACIAs.*

variety of synchronous formats, including XDLC and bisync. Western Digital's WD2511 packet-network interface IC is a dual-channel device that supports X.25 LAPB protocols, among others. It comes in a 48-pin DIP. Zilog's Z8440 serial-I/O controller handles X.25 protocols, provides CRC error correction, and works with the company's Z80 μP.

Take the custom route

An alternative to using standard peripheral ICs is to customize your datacomm-protocol designs. The latest generation of application-specific ICs (ASICs) includes devices fabricated specifically for datacomm-protocol interfaces. For example, Cirrus Logic provides datacomm chips with ASIC features at costs comparable to those of standard ICs. The company's semistandard DCOM-130 multichannel universal synchronous/asynchronous receiver/transmitter (MUSART) chip handles asynchronous character-oriented protocols and packet-switching synchronous protocols such as bisync, XDLC, or S/S (see **box**, "MUSART can customize your datacomm language").

The multiprotocol ICs discussed thus far all support the X.25 protocol, but other synchronous datacomm formats are also popular in computer data links employing packet-switching protocols. If you're working with a specific synchronous protocol and won't require X.25 support, you can use a chip designed specifically for that protocol. For example, IBM systems generally incorporate the XDLC format in their serial links. For datacomm designs in this realm, Intel makes the 8273 HDLC/SDLC protocol controller, which can handle synchronous data transfers at speeds as high as 64k baud. The 8273 operates from a single 5V supply, comes in a 40-pin DIP, and sells for $25 (1000).

Functionally compatible but not pin compatible with the 8273 is Western Digital's WD1935 HDLC/SDLC controller, which can directly drive TTL peripheral circuitry. Because it features double data buffering and a complete set of modem-control signals, the WD1935 is useful in systems employing serial communications links between widely dispersed devices.

Asynchronous systems are still viable

Barry Barrett, engineering manager for National Semiconductor's NSC-800 peripheral ICs, believes that IBM will eventually push the industry toward some form of synchronous XDLC protocol, and he also says that CCITT and IEEE will be instrumental in setting the final standards. Yet despite the gradual shift among system specifiers toward synchronous multipoint networks, asynchronous point-to-point and timesharing systems are still common, comply with accepted protocol standards, and are relatively inexpensive to construct.

Consequently, you should still give careful consideration to the wide selection of programmable character-switching UARTs and USARTs when evaluating a design for a datacomm link. Such standard UARTs are available from Fujitsu, Gould/AMI, National Semiconductor, Harris, Standard Microsystems, Western Digital, and others (**Table 1**).

National's NMOS INS8250A octal UART, for example, is still extensively used as an asynchronous communications component of the IBM PC/XT and compatible PCs, according to Barrett. The $8 (100) chip provides read/write registers and double buffering. National also makes the $10.70 (100) INS16450 UART for IBM PC/AT serial datacomm channels.

The conventional UART is now appearing in CMOS versions. Last October, Harris Corp introduced its 82C50A, a low-power CMOS version of the NMOS 8250. The Harris part consumes 1 mA/MHz, which translates into a 90% power reduction compared with the NMOS device. The company's commercial versions, the CP82C50A-5 (plastic DIP) and the CS82C50A-5

Text continued on pg 112

TABLE 1—REPRESENTATIVE SINGLE-CHANNEL, FULL-DUPLEX UARTs

MANUFACTURER	MODEL	SUPPLY VOLTAGE (V TYP)	MAXIMUM DATA RATE (BAUD)	CHIP PROCESS	PACKAGE	PROGRAMMED INTERRUPTS	ERROR FLAGS	COUNTER/ TIMER(S)	COMMENTS
FUJITSU	MB8868A	5	50k	NMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
GENERAL INSTRUMENT	AY-5-1013	+5/−12	40k	NMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
GOULD/AMI	S1602	5	50k	NMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
HARRIS	HD-6402	5	1M	CMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
INTEL	8256AH	5	1M	NMOS	40-PIN DIP	YES	NO	YES	8-BIT PROGRAMMABLE I/O PORTS
MODULAR SEMICONDUCTOR	MS68/ 88C691	5	250k	CMOS	24-PIN DIP, 26-PIN PLCC	YES	NO	YES	LOW-POWER STANDBY MODE; SECOND SOURCE FOR SIGNETICS SCC2691
	MS82C50A MS16C450	5	56k	CMOS	40-PIN DIP, 44-PIN PLCC	YES	NO	NO	SECOND SOURCE FOR NATIONAL 82C50A, 16C450
NATIONAL SEMICONDUCTOR	INS8250A/ 82C50A INS16450/ 16C450	5	56k	NMOS/ CMOS	40-PIN DIP, 44-PIN PLCC	YES	NO	NO	ACCESSIBLE REGISTERS; INTERNAL DIAGNOSTICS; MODEM-CONTROL PINS
SIGNETICS	SCC2691	5	38.4k	CMOS	24-PIN DIP, 26-PIN PLCC	YES	NO	YES	SEVEN MASKABLE INTERRUPT CONDITIONS
STANDARD MICROSYSTEMS	COM-1863	5	62.5k	CMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
TEXAS INSTRUMENTS	TMS-6011	+5/−12	12.5k	NMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT; AUTO CLOCK/DATA SYNC
WESTERN DIGITAL	TR1863	5	62.5k	NMOS	40-PIN DIP	NO	YES	NO	AUTO START BIT/ AUTO CLOCK/DATA SYNC

MUSART can customize your datacomm language

Because costs for conventional development of digital hardware using standard glue-logic parts have increased noticeably over the past few years, designers of communications equipment have shown increasing interest in applications-specific ICs (ASICs). Nevertheless, interfaces with older designs using previous-generation technology have kept standard digital ICs in the designer's notebook. In response to demands by designers to maintain compatibility with older designs, more and more ASIC manufacturers are providing lines of standard or semistandard ICs to supplement their full-custom or semicustom ASICs.

Unlike semicustom ASICs, semistandard ICs have predefined functional blocks similar to those found in standard ICs. The "semi" in "semistandard" refers to the optional features such ICs provide. For instance, semistandard datacomm ICs have such predefined functional blocks as internal UARTs and counter/timers and such optional features as DMA interface logic.

Semistandard trend gaining

The trend toward providing semistandard ICs has been gaining popularity within the datacomm IC field because many designers prefer to draw upon well-defined functional circuits like UARTs rather than fabricate an entire ASIC from basic semicustom elements like gates and flip-flops. One example of a semistandard datacomm IC is the multichannel universal synchronous/asynchronous receiver/transmitter (MUSART) from Cirrus Logic **(Fig A)**. This IC allows both chip- and system-design engineers to cope with the requirements of datacomm multichannel serial I/O interfaces, especially for PC peripherals.

The company's DCOM-130, also called the Musketeer (multiuser system keyboard enhanced receiver/transmitter), is a specialized version of the MUSART. The Musketeer was developed to handle typical PC datacomm links, such as keyboard and printer interfaces, and to provide other options.

These options include four multiprotocol ports, all of which can be ASCII-type (RS-232C) ports and two of which can be ports for synchronous protocols like SNA-XDLC. By combining these channels on a single chip, the DCOM-130 takes the place of a quad-channel USART and a DMA controller. At the same time, other options permit adaptation to a particular μP interface. Systems access bisync ports on the Musketeer via the part's integral DMA controller, memory management unit, and internal FIFO buffers. You can allocate as many as eight counter/timers to the four serial channels to perform multiprotocol functions.

The degree of customization allowed with the Musketeer extends to such features as transmit and receive FIFOs, channel-priority encoding, and the I/O pins for each channel. The chip's internal interrupt structure and DMA control circuitry allows concurrent handling of synchronous and asynchronous datacomm protocols.

Shorten your design cycle

Obviously, one virtue of the semistandard approach is reduced design time. To help keep development times to a minimum, Cirrus Logic provides designers with its proprietary ASIC silicon compiler. You can expect about 16 to 20 weeks for first silicon on a design using the DCOM-130. Additional options require longer turnaround times. Pricing for the DCOM-130 varies from $25 to $35 (1000), including amortization of the NRE charge. The cost depends upon the extent of your performance specs, like operating speed and power consumption.

For applications that require full RS-232C control pinouts, Cirrus furnishes MUSART chips in 84-pin plastic leadless chip carriers (PLCCs). For simpler designs, the MUSART can also be packaged in a 68-pin PLCC. Other packaging is available upon request.

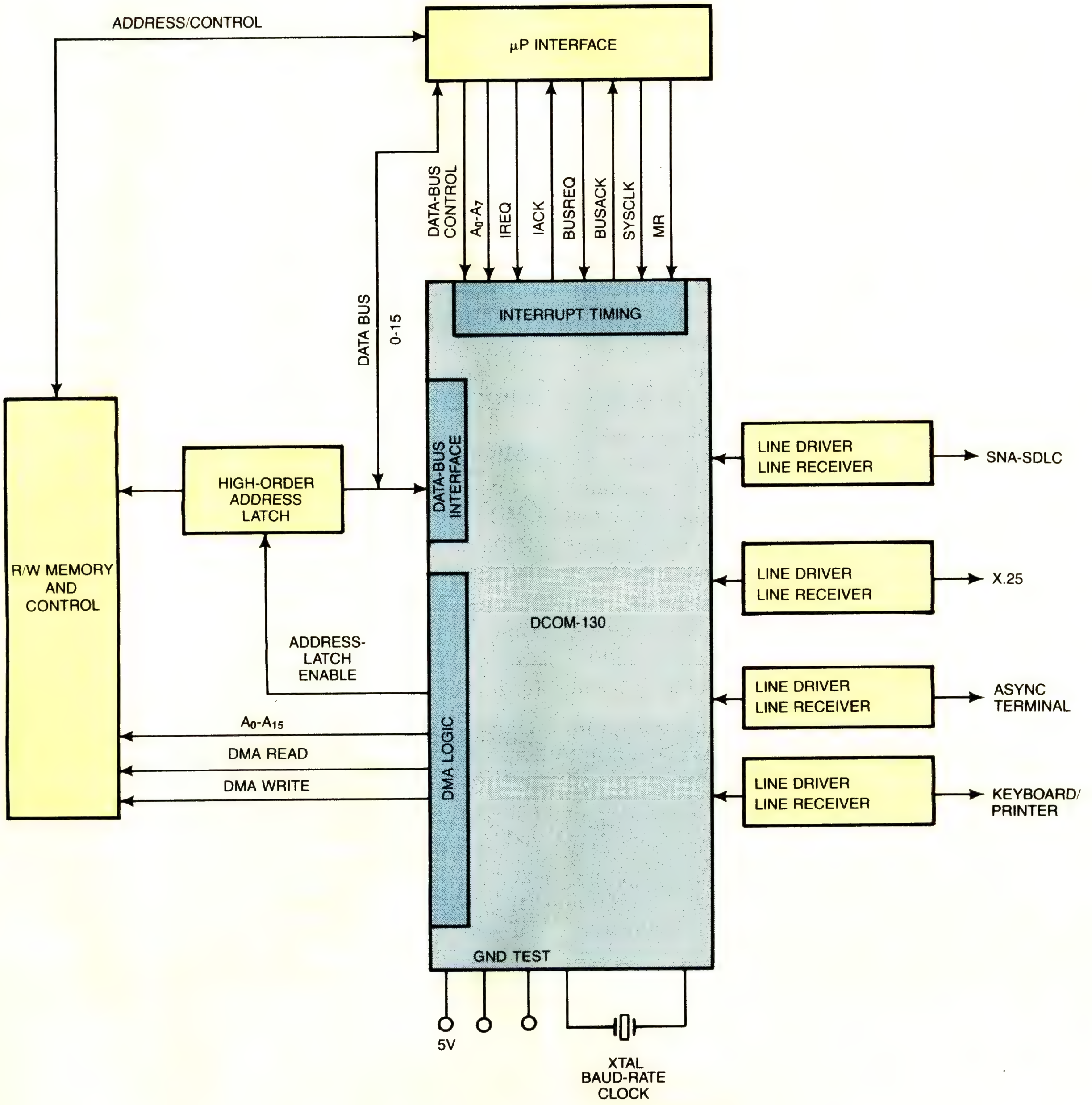


Fig A—With dual on-chip USRTs and UARTs, *the multiprotocol DCOM-130 Musketeer ASIC from Cirrus Logic allows designers to customize features such as Tx and Rx FIFOs, channel priority encoding, and separate I/O pins for each serial channel.*

An alternative to using standard peripheral ICs is to customize your datacomm protocol designs.

(PLCC), incorporate a 10-MHz clock and operate over 0 to 70°C. The 40-pin DIP version costs $10.81, and the 44-pin PLCC version sells for $14.05 (100). Harris also offers a military version of the device, the MD82C50A-5/B, in a 40-pin ceramic DIP. The device operates over −55 to +125°C and costs $69.55 (100).

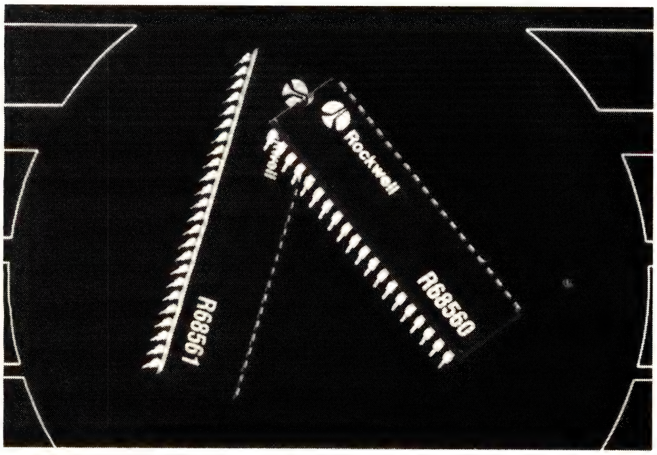
To help simplify multiport datacomm designs—to save board space, for example, or to realize full-duplex transmission without synchronizing two separate UARTs—you can move up to dual UARTs (DUARTs). For designs incorporating Z80 μPs, you can use Zilog's Z8470 dual asynchronous receiver/transmitter (DART). Yet another dual-port datacomm chip is Signetics's SCN2681/68681 DUART, which features programmable bit rates, internal 16-bit counter/timers, and multifunction channel modes. The 40-pin DIP and PLCC versions cost $4 (1000). Modular Semiconductor supplies a high-speed, CMOS pin-compatible version of the Signetics/Motorola -681 DUART, the MS88/68C681, which handles data rates as high as 2M bps.

Many of the new asynchronous devices are buffered and software programmable, which can help you simplify designs and provide you with greater control. For instance, the SCN2661/68661 enhanced programmable communications interface (EPCI) from Signetics has double-buffered transmitter and receiver connections and furnishes asynchronous and synchronous interfaces to intelligent terminals, front-end processors, and bisync adapters. It functions very much like a bisync USART and transmits data at 1M bps. The EPCI operates from a single 5V supply, is available in 24- or 28-pin DIPs or 26-pin PLCCs, and costs $2.50 (1000). Another device in this category is an enhanced USART, the UC1671 Astro (asynchronous/synchronous transmitter/receiver) from Western Digital. The UC1671 can operate on a multiplexed data-bus structure.

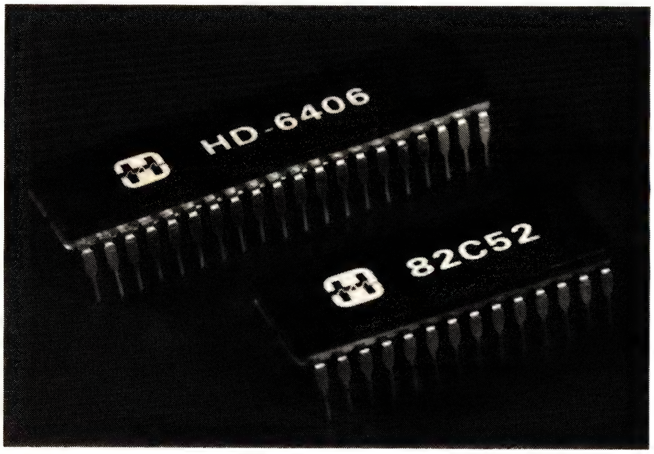
Designs requiring more complex asynchronous data transfers between 8-bit μPs over bidirectional bus-organized systems can benefit from the use of ACIAs. One such device is Harris's CMOS HD-6406 programmable ACIA. The -6406 handles both DMA and modem handshaking functions on chip. The part dissipates only 100 mW, includes a 16-MHz clock, operates from a single 5V supply, and allows software selection of 72 different data rates. It comes in a 40-pin plastic DIP and costs $15.56 (100). Functionally similar to the -6406 is Harris's CMOS CP82C52 serial controller interface, which includes an on-chip 1M-baud UART, a bit-rate generator, line-break detection, and loop-back and auto-echo modes. Supplied in a 28-pin plastic DIP, the CP82C52 sells for $13.50 (100).

CMOS incarnations of existing ASICs

Last July, Gould/AMI introduced a pin-compatible CMOS version of its NMOS S6551 ACIA, the S65C51 (Mitel is a second source with its MD-65C51). The S65C51 features software-programmable word lengths, bit rates, interrupt control, and status registers. Operating from a single 5V supply, the S65C51 comes in a 28-pin package and draws only 2 mA/MHz of clock frequency. The price is $3.75 for the plastic-DIP ver-



Designed to work with members of the 68000 μP family, *Rockwell International's R68560/1 programmable multiprotocol communications controller ICs can handle full-duplex asynchronous, bit-synchronous, or byte-synchronous data exchanges using polled, interrupt-driven, and 2-channel DMA transfers.*



These CMOS datacomm-protocol devices, *Harris's 82C52 serial controller interface and HD-6406 programmable asynchronous communications interface, contain on-chip bit-rate generators and 1M-baud UARTs. Both parts feature a bidirectional data bus, line-break generation, and detection with loop-back and auto-echo modes.*

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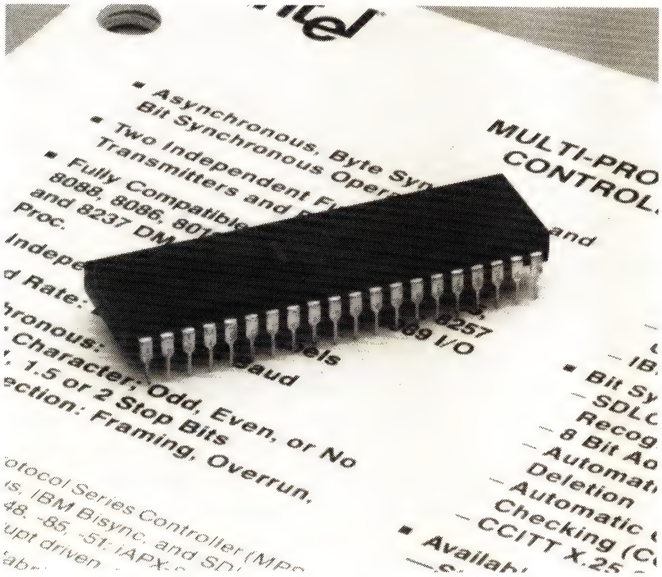
CIRCLE NO 71

Synchronous datacomm formats besides X.25 are popular with computer data links employing packet-switching protocols.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— SDLC
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— Automatic Checking (CCITT X.25)
• Available

To accommodate programmable multiport datacomm designs, *you can daisy-chain Intel's HMOS 8274 multiprotocol serial controller for vectored-interrupt operation with 8088/86 μPs.*

sion and $3.95 (1000) for the PLCC version.

A chip that's functionally similar to the S65C51 is Hitachi's programmable CMOS ACIA, the HD6350, for use with 6800 μPs. It's compatible with the company's NMOS HD6850 and Motorola's MC6850 ACIAs. For multiport μP interfaces, Rockwell makes two CMOS dual ACIAs, each with buffered receivers and transmitters. The R65C52 and the R68C552 chips are programmable and come in 40-pin plastic or ceramic DIPs. Plastic-DIP versions of the R65C52 and the R68C552 cost $7.30 and $8.05 (1000), respectively. **EDN**

Reference

1. Sterk, Don, "Full-duplex support on mainframes," *Usenix Technical Conference Proceedings*, January 1986, pg 165.

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

Manufacturers of datacomm protocol ICs

For more information on the datacomm protocol ICs such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

AT&T Technologies
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Circle No 721

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Sunnyvale, CA 94088
(408) 739-7700
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Hauppauge, NY 11788
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Circle No 723

Western Digital Corp
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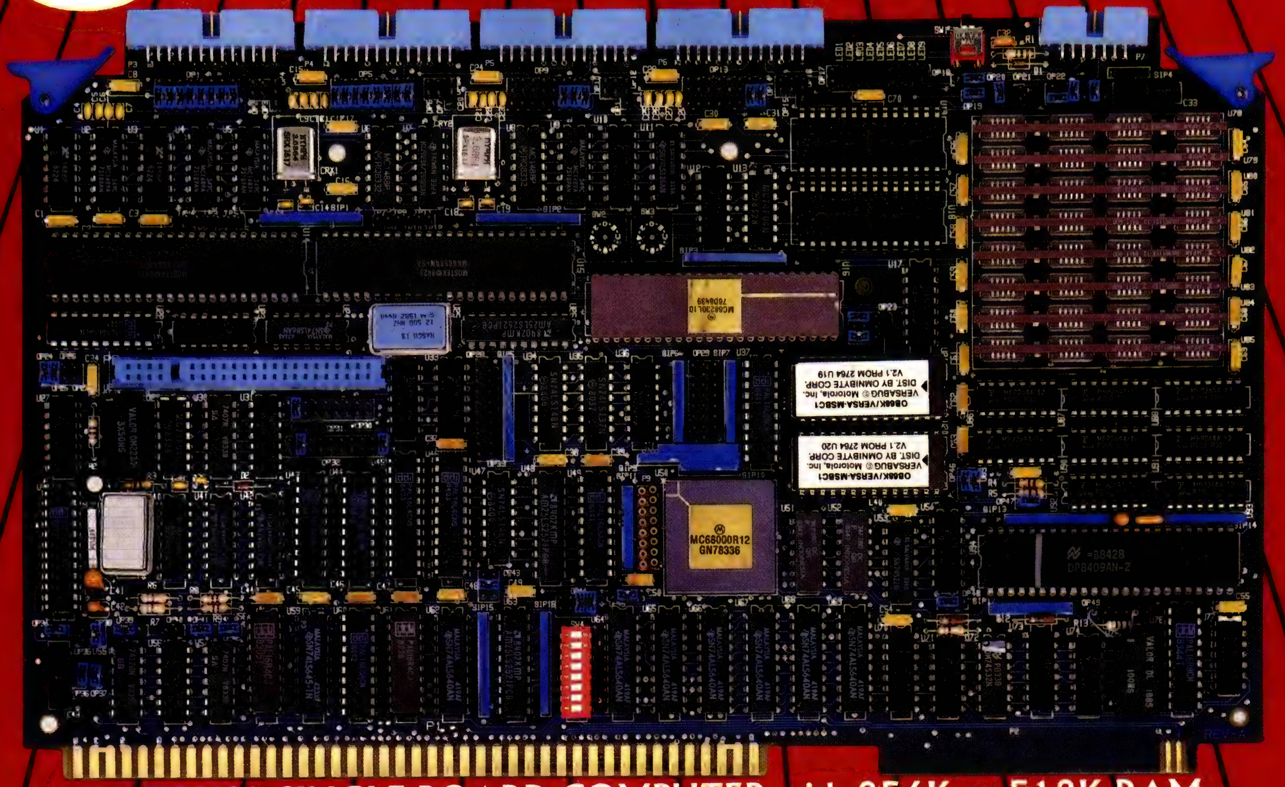

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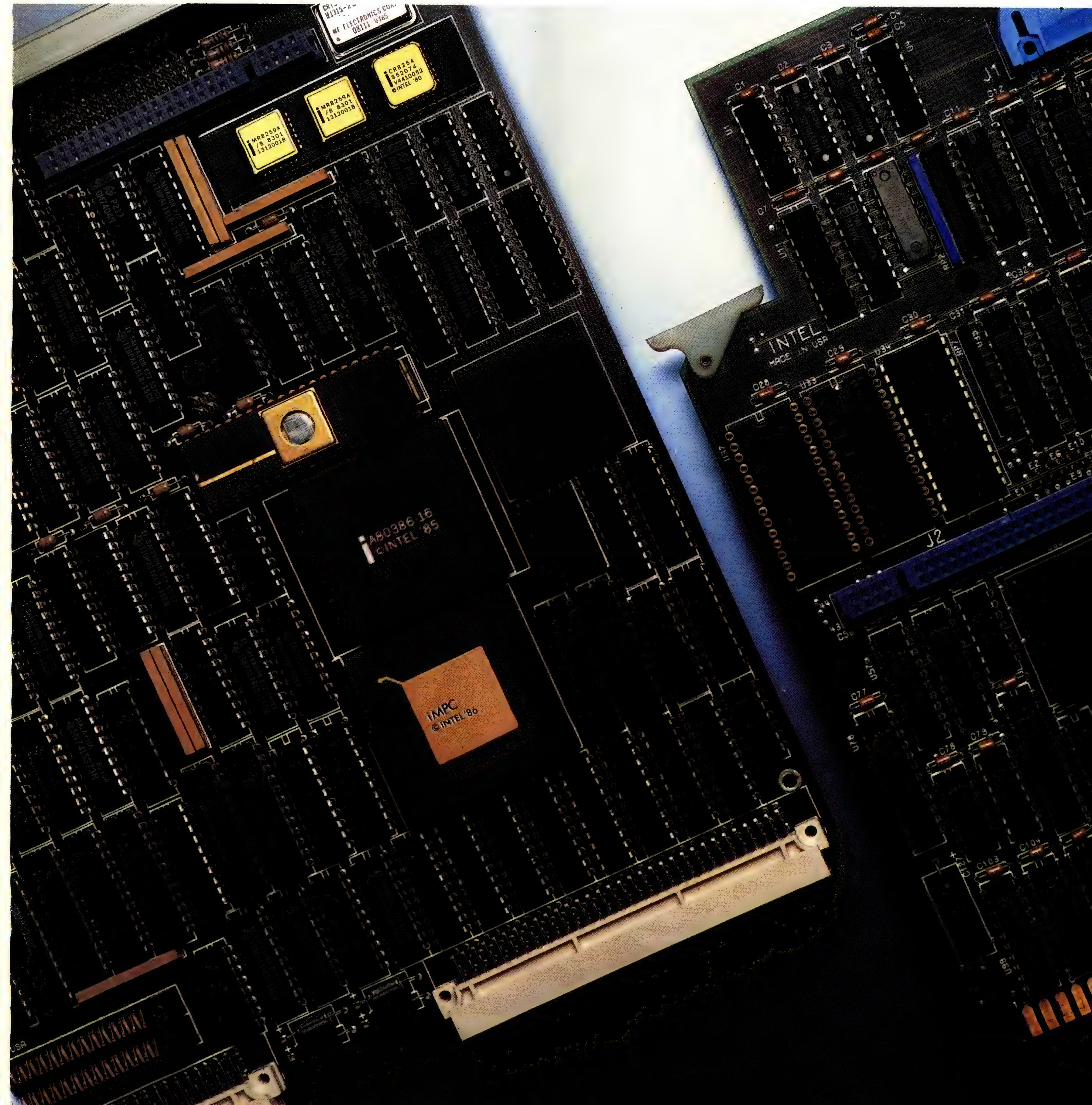

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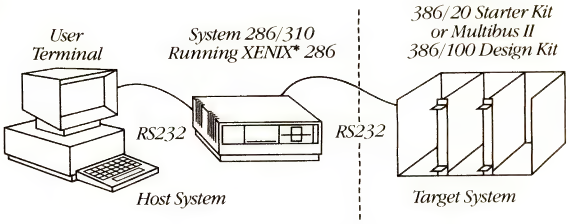
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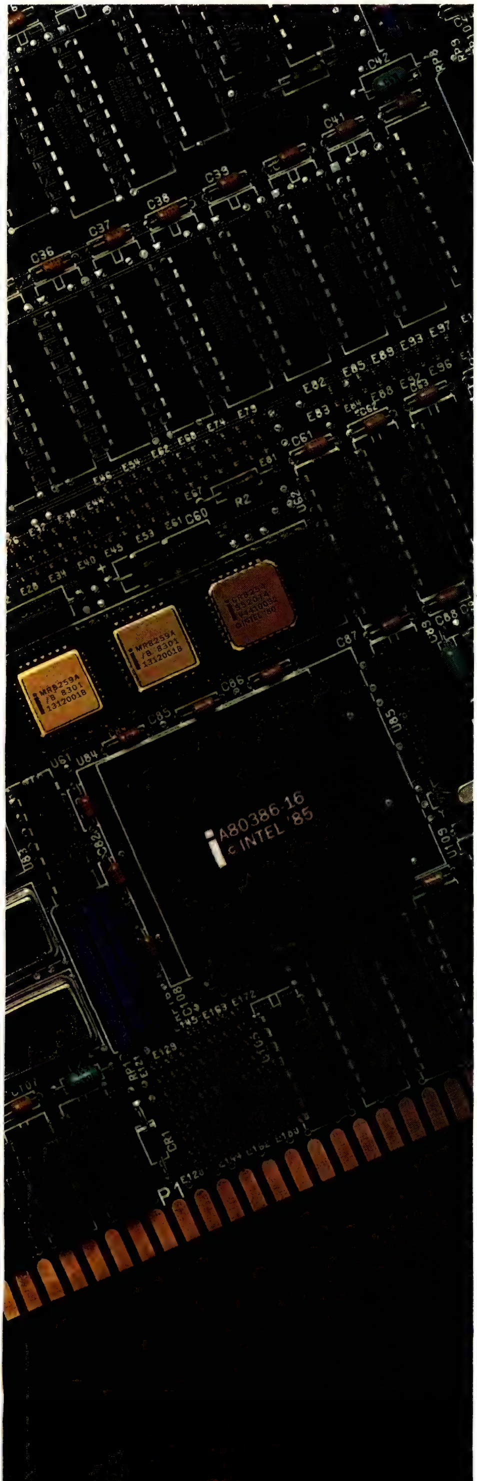

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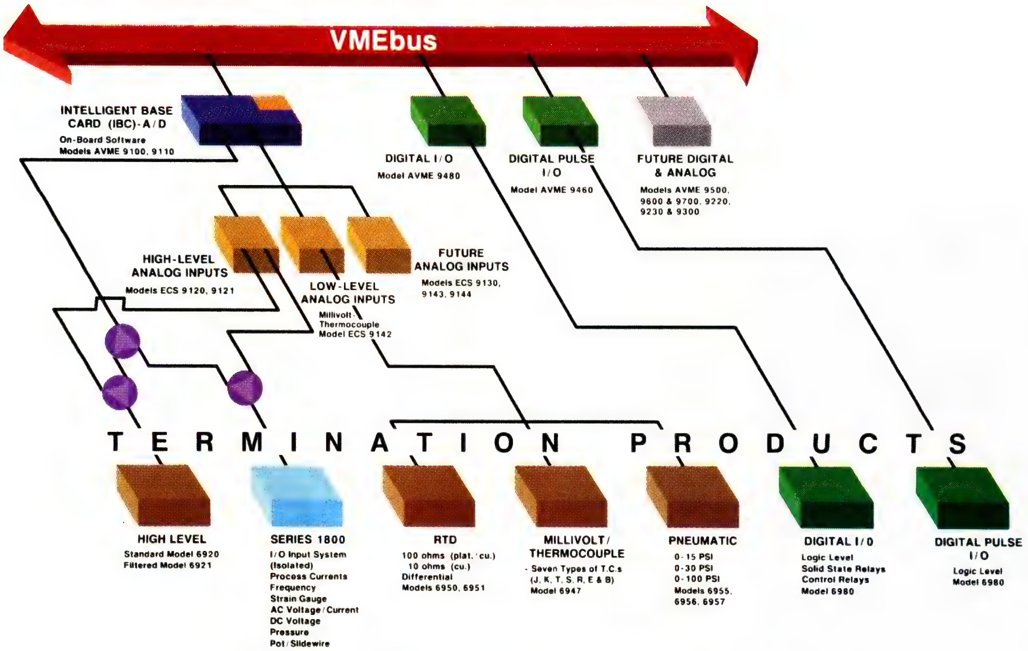

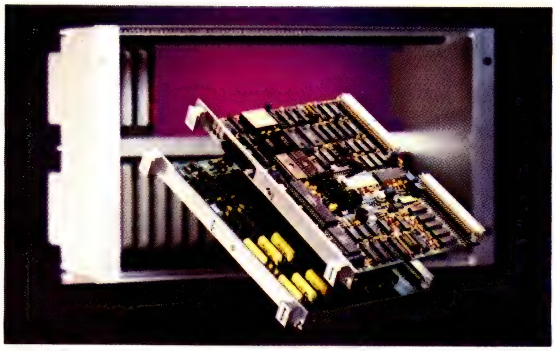

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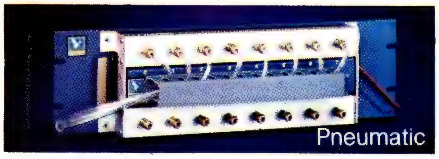
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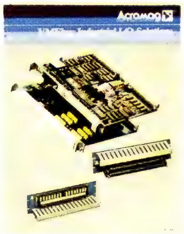

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ICs simplify design of single-sideband receivers

Single-sideband transmission has served well for decades in radio and telephone systems. Unfortunately, cost considerations have historically limited its use to only the most demanding applications. Today, state-of-the-art ICs allow you to design low-cost SSB receivers that perform as well as their expensive predecessors.

Robert J Zavrel, *Signetics Corp*

Single-sideband (SSB) transmission offers many advantages over FM and full-carrier double-sideband modulation schemes—more efficient spectrum use, better signal-to-noise ratios at low signal levels, and better transmitter efficiency. Unfortunately, SSB systems have historically required the use of expensive multipole filters. Today, however, some new RF and digital ICs allow you to circumvent the need for these filters. You can use these ICs to good advantage in developing a cost-effective SSB receiver.

Good SSB-receiver design requires that you know a little about the three basic methods of single-sideband generation. All three methods use a balanced modulator to produce a double-sideband, suppressed-carrier signal. The undesired sideband is then removed by high-Q multipole filters (the filter method), by phase and amplitude nulling (the phasing method), or by the Weaver method. The reciprocal of the generator functions is used to develop sideband detectors.

Generators accept audio inputs and produce the SSB signal; detectors receive the SSB signal and reproduce the audio signal. The sideband signal is typically in the radio-frequency (RF) range, so you can amplify it and apply it to an antenna or use it as a subcarrier. It's worth noting that all three methods of removing a sideband are complementary; an SSB signal produced by the Weaver method can be reproduced by the phasing method, etc.

In a generation and detection technique using the traditional filter method, the generator **(Fig 1a)** produces a double-sideband signal, and the balanced modulator nulls the carrier. A high-Q crystal-type bandpass filter then removes the undesired sideband. The transmit mixer then converts the SSB signal to the desired output frequency.

The detection scheme **(Fig 1b)** simply reverses the operation. A receive mixer converts the input frequency to the intermediate frequency (IF). The filter has a narrow response and passes only the required SSB

Single-sideband transmission offers many advantages over FM and full-carrier, double-sideband modulation schemes.

bandwidth. The product detector demodulates the signal.

This SSB signal-generation method has one major drawback. The filter is tuned to one fixed frequency. As a result, you'll need to incorporate a number of transmit and receive mixers to satisfy applications involving multifrequency operation.

Phasing method not suited to voice band

Fig 2 shows block diagrams of generator and detector circuits for implementing the phasing method. In the detector **(Fig 2a)**, the input signal feeds in phase to two RF mixers. A local oscillator (LO) supplies a second signal to the mixers in quadrature. Summing the differentiated output of one of the mixers with the output of the second mixer produces an audio output.

In most cases, the mixers will have an output in the audio passband (300 to 3000 Hz). Running the passband through the differentiator circuit imposes a 90° phase shift over more than three octaves. As a result, it's quite difficult to use the phasing method for voice-band SSB applications.

The phasing method employs a generator **(Fig 2b)** that duplicates the circuit elements found in the detector. Note that in the generator, the differentiator (phase shifter) is located between the audio input and the mixer. In the generator circuit, a divide-by-4 flip-flop provides the sin(yt) and cos(yt) signals for the mixer. As a result, the clock signal's frequency must be four times the RF output frequency.

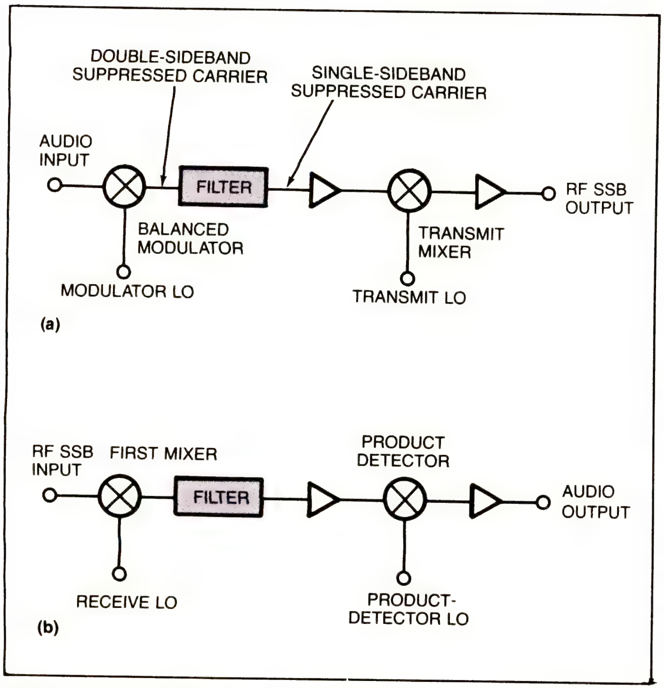

Fig 1—In the traditional filter method, the generator (a) *produces a double-sideband signal, and the balanced modulator nulls the carrier. The detector **(b)** simply reverses the generation procedure to develop the audio output.*

Versatility in datacomm systems

You can use the phasing method for FSK, PSK, and quadrature-PSK datacomm systems. In an FSK situation, for example, you can alternately key two discrete frequencies to correspond to ones and zeros. By tuning the receiver at the halfway point, you can let these two frequencies represent the upper- and lower-sideband signals. When you implement rectification and filtering, you can use the simultaneous upper/lower-sideband detection concept to drive both clock inputs of a flip-flop. This type of FSK receiver can exhibit better sensitivity characteristics than traditional FM receivers. In addition, the scheme uses discrete frequencies, so you will not have to employ a broadband phase shifter; simple discrete RC networks will suffice.

The Weaver method **(Fig 3)** eliminates the difficulty of having to maintain an accurate broadband phase shift in voice communications systems. A derivation of the phasing technique, the Weaver method does require more circuit elements (four mixers as opposed to two, for example) in both the generator **(Fig 3a)** and the detector **(Fig 3b)**.

Low-frequency subcarrier vs phase shift

The basic difference between the two schemes is that the Weaver method uses a low-frequency (1.8-kHz) subcarrier in quadrature, rather than a broadband, 90° audio phase shift. The desired sideband folds over the 1.8-kHz subcarrier, and its energy appears between 0 and 1.5 kHz. The undesired energy appears at least 600 Hz away (above 2.1 kHz). As a consequence, you can reject the undesired sideband with a simple lowpass filter.

It's much easier to design a filter with a steep lowpass response than it is to achieve the accurate phase and amplitude balance that the phasing method requires. As a result, the Weaver method will have much better sideband rejection than that obtainable with the phasing method.

Once you've chosen the manner in which you wish to develop the SSB signal, you're ready to add the other circuits that help complete an SSB receiver. You'll need quadrature-dual-mixer circuits for the first stage when

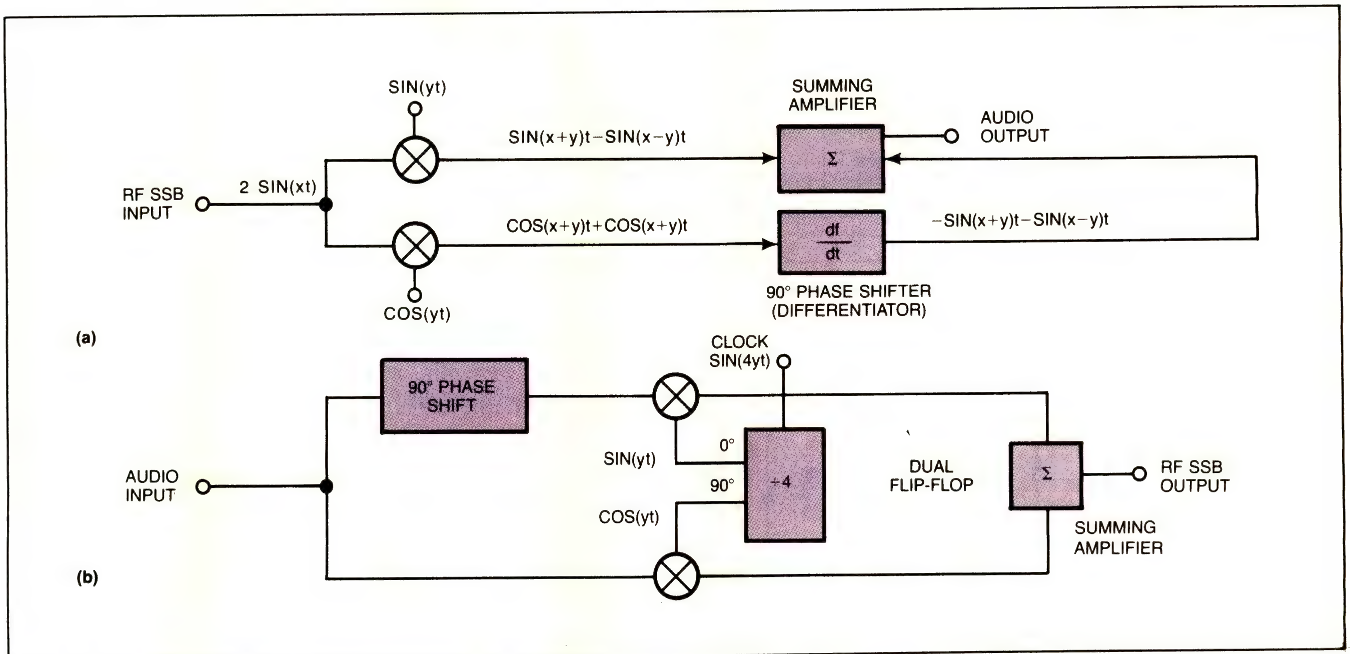

*Fig 2—**The input signal feeds in phase to two RF mixers** in the phasing-method detector **(a)**. A local oscillator (LO) supplies a second signal to the mixers in quadrature. In the generator **(b)**, a divide-by-4 flip-flop provides the sin(yt) and cos(yt) signals for the mixer.*

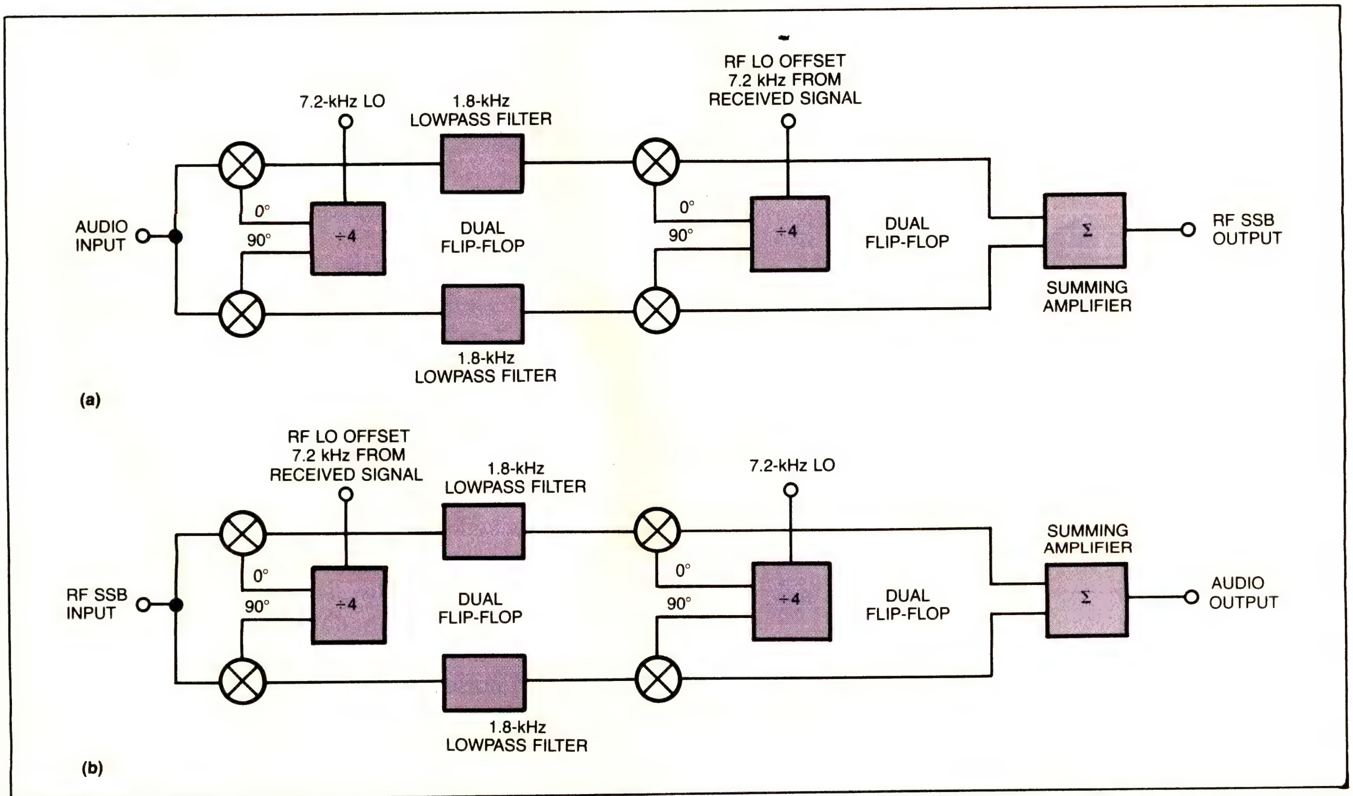

*Fig 3—**There's no need to maintain accurate phase shift** when using the Weaver method in voice systems. It does require more circuit elements than the phasing method—four mixers in both the generator **(a)** and the detector **(b)**, for example.*

Generators receive an audio signal and produce an SSB signal; detectors receive the SSB signal and reproduce the audio signal.

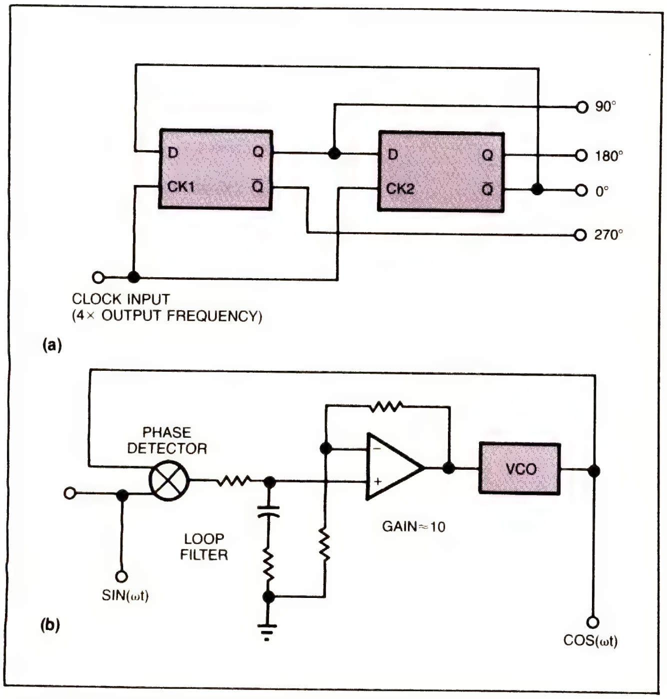

Fig 4—You need quadrature dual mixers *whether you're using the phasing or the Weaver method. The mixer in* ***a*** *maintains good phase integrity at clock rates ranging to several megahertz. Clock and operating frequencies are equal in the mixer circuit* ***(b),*** *which marks an advantage over the flip-flop design.*

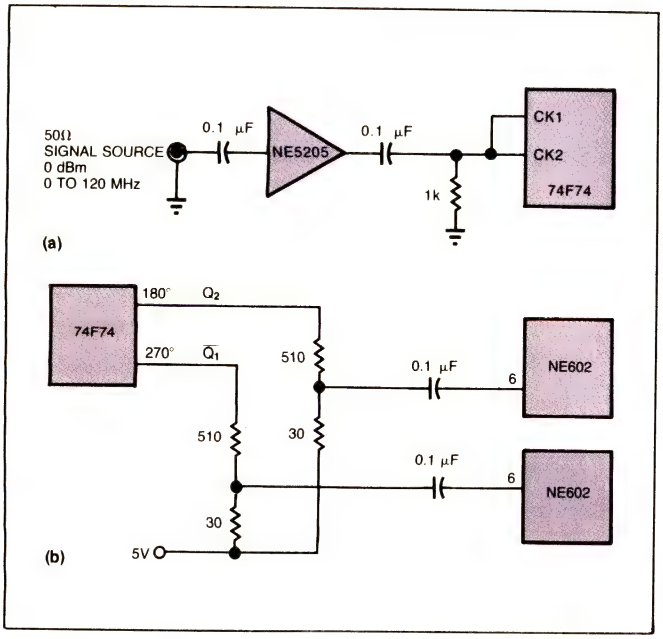

Fig 5—You can effectively drive the 74F74 *and other TTL gates with the circuit shown in* ***a.*** *The total resistance in the interface circuit* ***(b)*** *establishes a conservative current drain (approximately 10 mA) from the 74F74, and the divider tap optimizes NE602 operation.*

using the Weaver method. **Fig 4** illustrates two methods of obtaining quadrature LO signals for dual-mixer applications. Both circuits are inherently broadband circuits; they are far more flexible than designs using passive LC circuits (which fail to maintain a quadrature relationship when the operating frequency changes), and they do not require adjustments. In addition, the circuits shown in **Fig 4** are not limited to SSB applications; you can also apply them in FSK, PSK, and quadrature-PSK digital communications systems.

In **Fig 4a**'s circuit, a divide-by-4 dual flip-flop generates all four quadrature signals. Most of the popular dual flip-flops will work in this circuit; the choice depends on the application. This example employs the HEF4013 CMOS device, which consumes little power and maintains excellent phase integrity at clock rates ranging to several megahertz. As a result, it will work quite well at the ubiquitous 455-kHz intermediate frequency.

For higher clock rates (to 120 MHz), the fast-TTL 74F74 is a good choice for the flip-flop. Tests on this device at 30-MHz operating frequencies show good results—greater than 20-dB SSB rejection. At frequencies in the neighborhood of 5 MHz, use of the 74F74 will result in sideband rejection of nearly 40 dB. The ultimate low-frequency rejection is mainly a function of the audio phase shifter. You can improve performance by employing resistors and capacitors with tighter tolerances in the phase shifter.

Match clock and operating frequencies

The circuit shown in **Fig 4b** illustrates a different technique for producing a broadband quadrature phase shift for the LO. In this case, the clock and operating frequencies are identical—an advantage when compared with the flip-flop circuit, because you don't need the high-speed components. Phase accuracy, however, is more difficult to achieve.

A phase-locked loop (PLL) will maintain a quadrature phase relationship when the loop is closed and the VCO voltage is 0V. The dc amplifier enhances the accuracy of the quadrature output by providing gain for the VCO control circuit. PLL circuits tend to be noisy, however, and noise can be a problem. Sideband noise is troublesome in both SSB and FM systems, but SSB transmission is less sensitive than frequency modulation to phase noise in the LO.

After developing the LO signals, you have to provide some drive circuitry. The circuit shown in **Fig 5a**

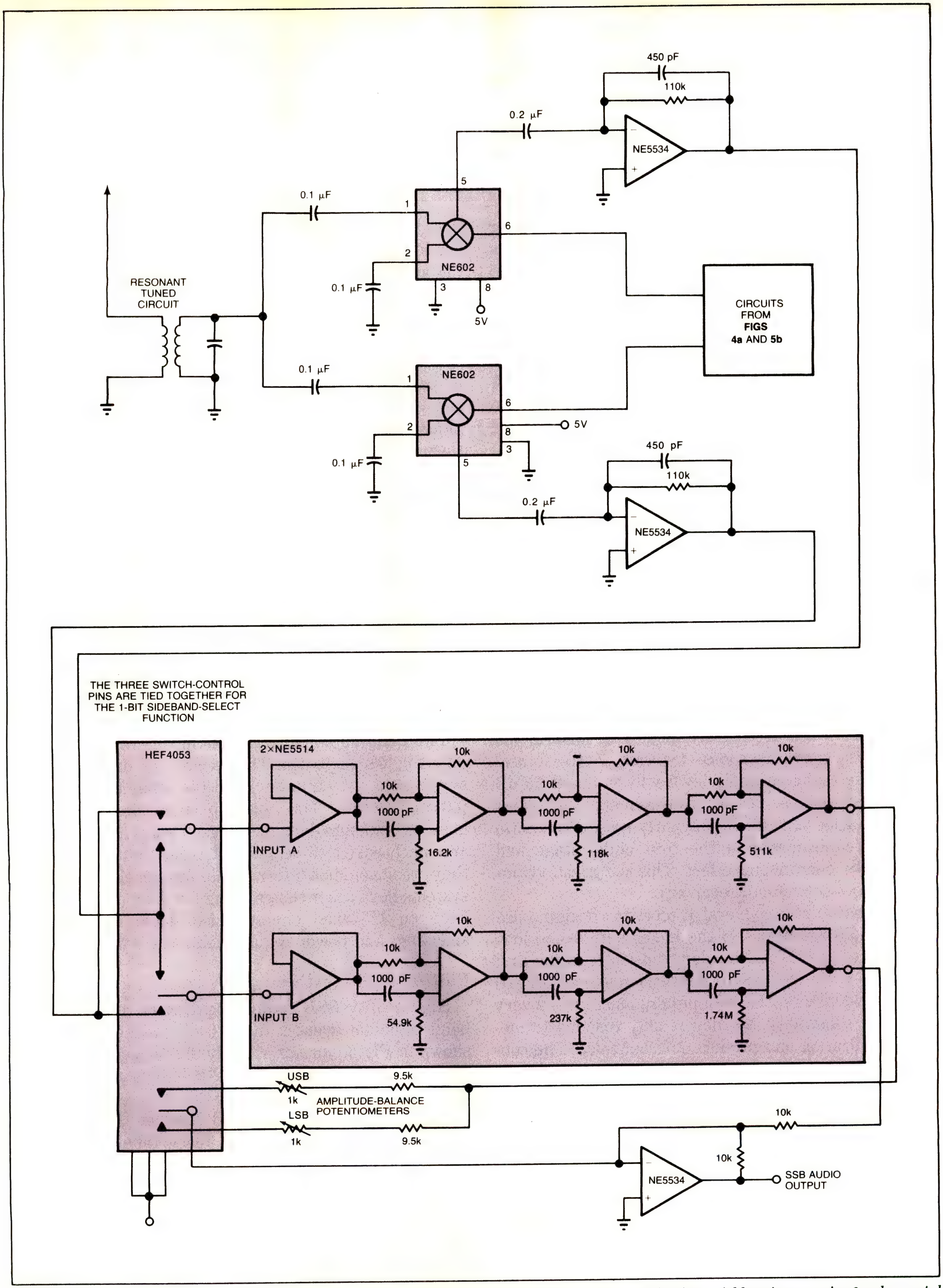

Fig 6—You can reliably obtain 35-dB rejection levels *using this circuit in direct-conversion applications. Add an inexpensive 2-pole crystal or ceramic filter and you will realize the required 70-dB sideband rejection levels.*

You can use the phasing method of SSB signal generation in FSK, PSK, and quadrature-PSK datacomm systems.

provides an effective means of driving the 74F74 (or other TTL gates) with an analog LO. Assuming you're using 50Ω input and output impedances, the NE5205 amplifier provides approximately 20 dB of gain from dc to 450 MHz.

External-component requirements are minimal. The 1-kΩ value of the resistor is about optimum for pulling the input voltage down near the logic threshold. A 0-dBm output level will drive the NE5205 and 74F74 to 120 MHz. By cascading two NE5205s, you can increase the sensitivity without sacrificing the wide bandwidth.

Fig 5b shows the interface circuitry between the 74F74 and the NE602 mixers' LO ports. The total resistance establishes a conservative current drain—about 10 mA—from the 74F74 outputs; the voltage-divider tap optimizes the operation of the NE602s. The low signal-source impedance helps maintain phase accuracy. For dc isolation, use a miniature ceramic device for the isolation capacitor.

Amplifying and switching functions

The use of active mixers like the NE602 will provide conversion gain—typically 18 dB. In more traditional applications, which use passive diode-ring mixers, you experience a conversion loss—typically 7 dB. Consequently, the detected audio level will be about 25 dB higher when you use the active-mixer approach. This fact means that you can significantly reduce the noise and gain requirements of the first audio stage and eliminate the microphonic effect. This is a great advantage in direct-conversion receivers.

Traditional direct-conversion-receiver designs use passive audio LC filters at the mixer output and low-noise discrete JFETs or bipolar transistors in the first audio stages. Because of the conversion loss associated with passive mixers, these amplifiers must have a very high audio sensitivity, so they readily respond to mechanical vibration and produce microphonics. The conversion gain available from an active mixer allows you to use a simple NE5534 op-amp stage (**Fig 6**), set up as an integrator to eliminate ultrasonic and RF instability.

You can use an HEF4053 CMOS-analog switch to provide the sideband-select function. This triple double-pole switch drives the phase network and engages one of two amplitude-balance potentiometers—one for each sideband. The buffer op amp shown with the two sideband-select sections reduces the total harmonic distortion, maintains amplitude integrity, and prevents changes in the resistance values of the filter network due to switch resistance. If the gain distribution within both legs of the receiver is consistent, you can eliminate the amplitude-balance potentiometers in less demanding applications.

Phase shifting comes next

In the phasing method, the broadband audio phase shifter (differentiator) is a critical stage. The analog all-pass differential phase-shift circuit shown in **Fig 6** is one of several available broadband phase-shift techniques. When you short the inputs together and drive them with a microphone circuit, the outputs will be 90° out of phase over the 300- to 3000-Hz band. This splitting and phase-shift action is required for phasing-generator operation.

For phasing demodulation, the circuit's filters receive their inputs from the two audio detectors. The filter outputs are then summed to null the undesired sideband and reinforce the desired sideband.

The filter circuit employs standard 1% values for the resistors and capacitors. You can improve gain tolerances by using 0.1% laser-trimmed integrated resistors. To maximize audio performance, it's best to use polystyrene, polypropelene, or Mylar capacitors.

Two quad op amps (NE5514s in this case) fit nicely into **Fig 6**'s approach. One section of each quad IC serves as a switch buffer, and the other three form a phasing section. The quad op amps also yield high linearity and high dynamic range. These characteristics are much easier to achieve at audio frequencies than they are at common intermediate frequencies. Audio IF systems have other things going for them as well: They have no IF-tuned circuits, they have no need for shielding, and power requirements are low.

Putting it all together

High-quality SSB radio specifications call for sideband rejection greater than 70 dB. Using the circuit shown in **Fig 6**, you can reliably obtain rejection levels of 35 dB. Add an inexpensive 2-pole crystal or ceramic filter, and you can meet the 70-dB requirement.

Fig 7 shows a complete SSB receiver that uses the phasing-filter technique. The block labelled "direct-conversion phasing SSB receiver" is **Fig 6**'s circuit. The antenna connects (via a bandpass filter) directly to the inputs of the NE602s.

The direct-conversion phasing SSB receiver circuit has a 10-dB signal/noise sensitivity of 0.5 μV and a dynamic range of about 80 dB. Single-tone audio harmonic distortion is less than 0.05%, and 2-tone intermodulation products are more than 55 dB down at RF

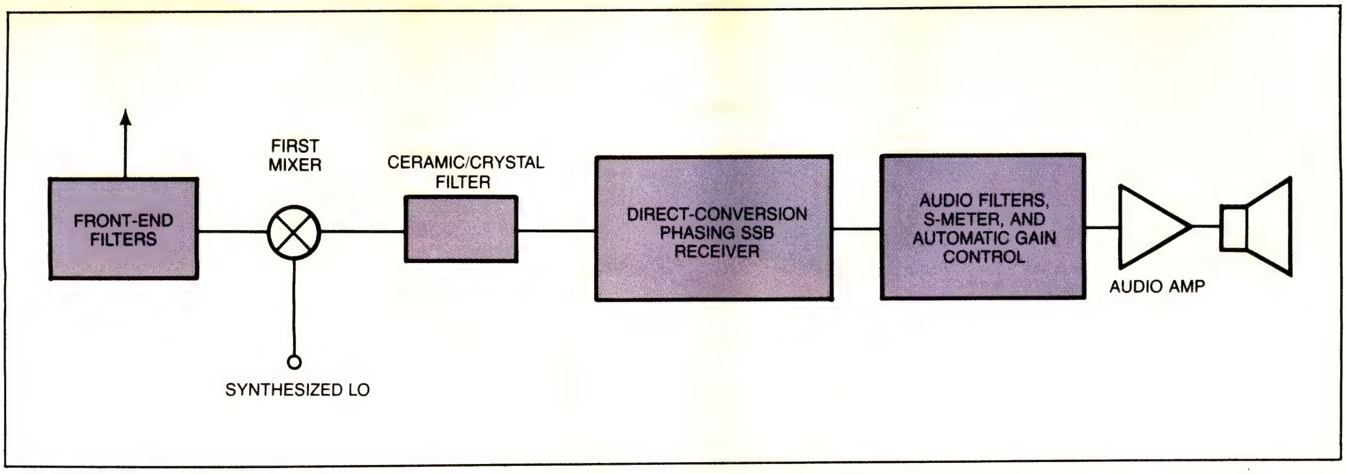
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*Fig 7—**Using the phasing filter technique,** you can design a complete, yet simple, SSB receiver. The antenna connects directly (via a bandpass filter) to the inputs of the NE602s' mixer stage.*

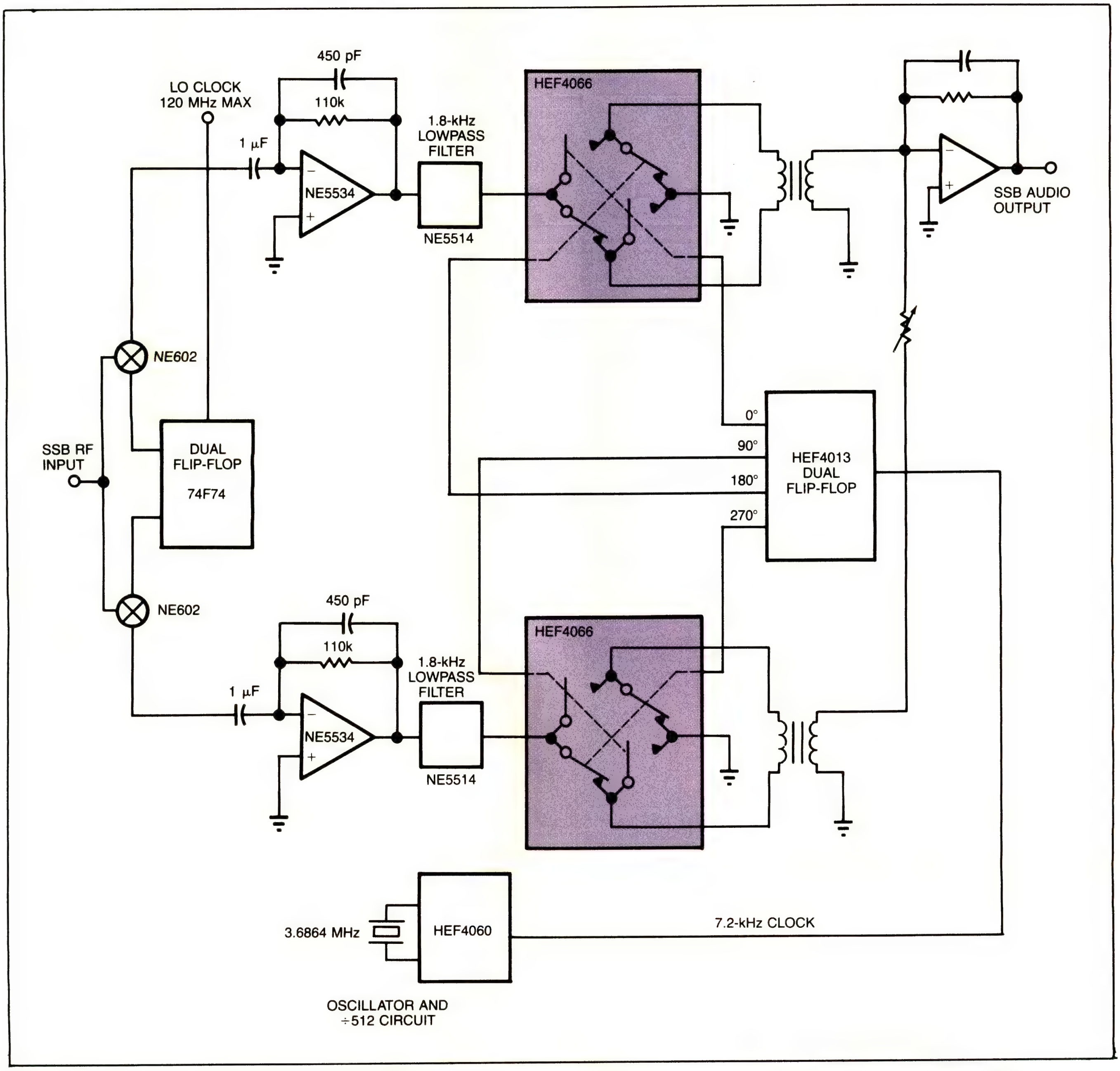

*Fig 8—**To minimize power drain,** you can use HEF4066 CMOS analog switches in the subcarrier stage of this experimental Weaver receiver circuit.*

input levels only 5 dB below the 1-dB compression point. The sideband rejection is about 38 dB at a 9-MHz operating frequency.

You can also use the same quadrature dual mixer in a Weaver-method receiver. **Fig 8** shows an experimental Weaver receiver circuit. The subcarrier stage here can use HEF4066 CMOS analog switches to minimize power drain.

A 1.8-kHz subcarrier requires a 7.2-kHz clock frequency. In the Weaver-method circuit, a common 3.6864-MHz crystal combines with the HEF4060 oscillator and ÷512 circuit to provide the required clock signal. When you use switched-capacitor filters for the lowpass audio circuits, a single clock generator (with appropriate dividers) suffices for all circuit-timing signals. **EDN**

Author's biography

Robert Zavrel is a senior applications engineer in the Linear Division of Signetics Corp (Sunnyvale, CA). In this position, he is involved in the design of RF and audio products. He has been with the company 1½ years. Robert has a BS in physics from the University of Oregon and is a member of the AES and the IEEE. He counts dabbling in amateur radio, building model railroads, and listening to classical music among his hobbies.

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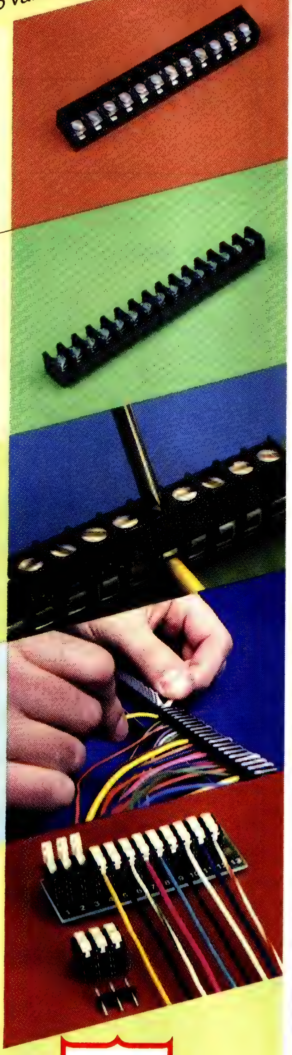

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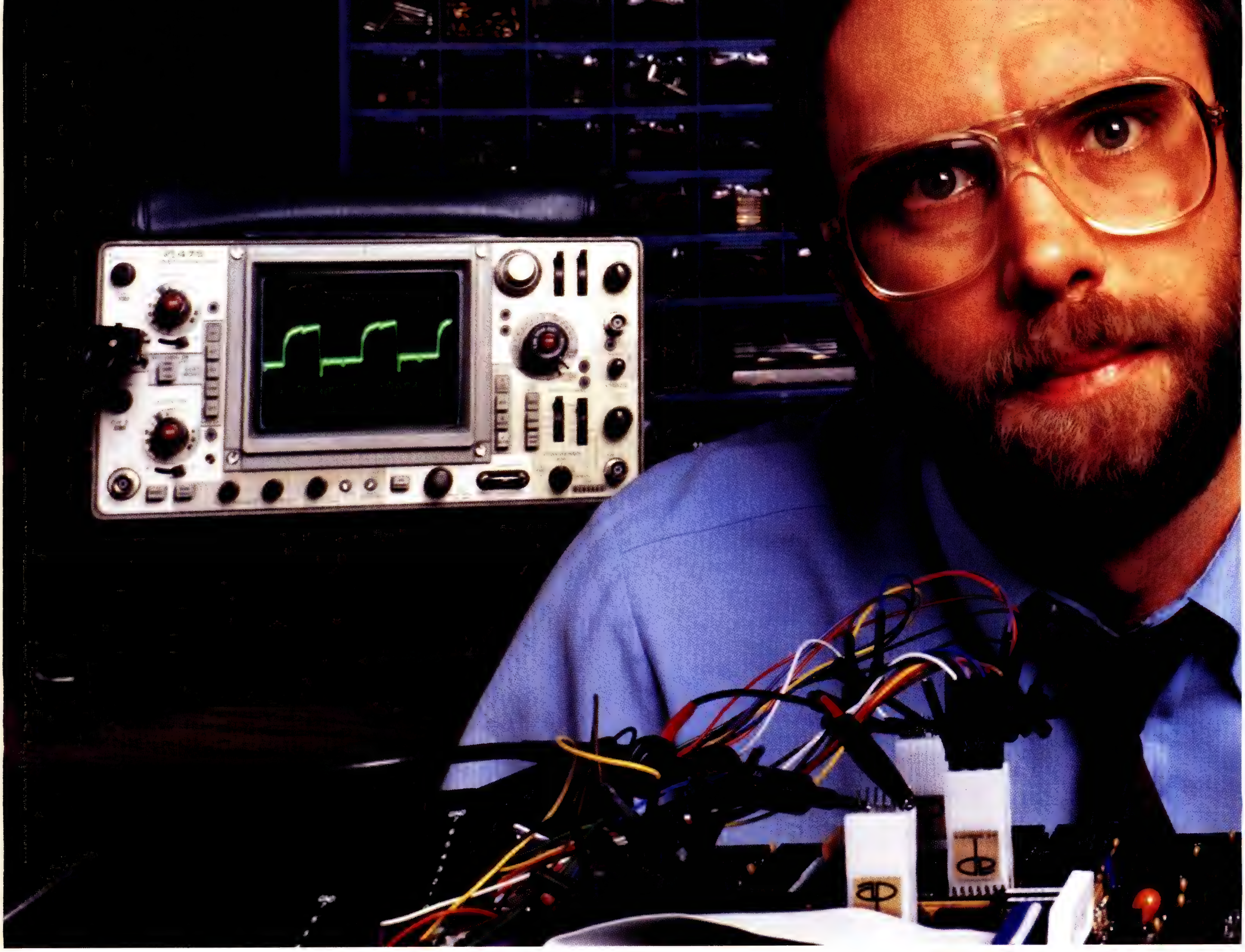

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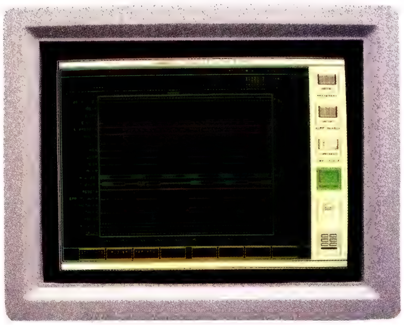

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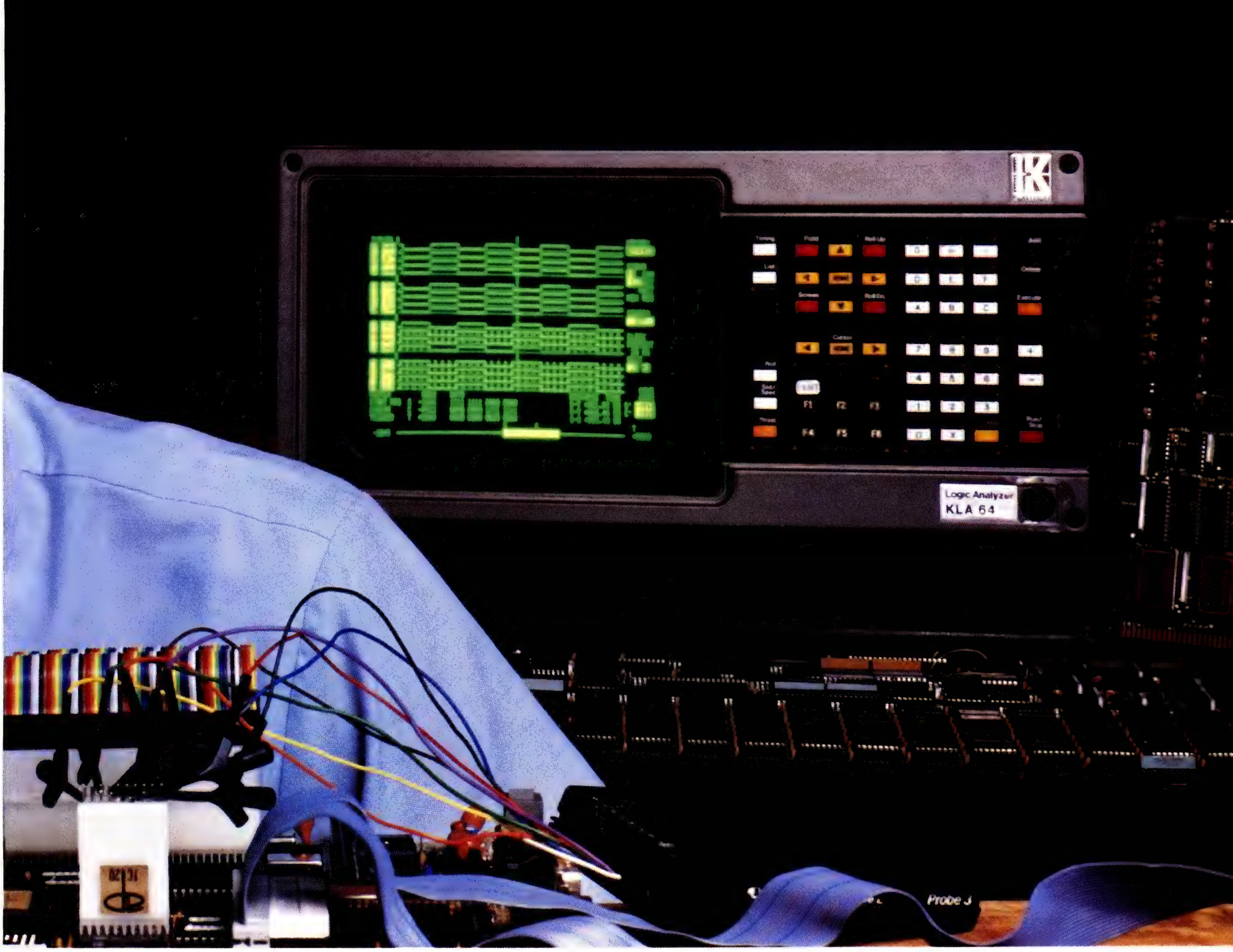

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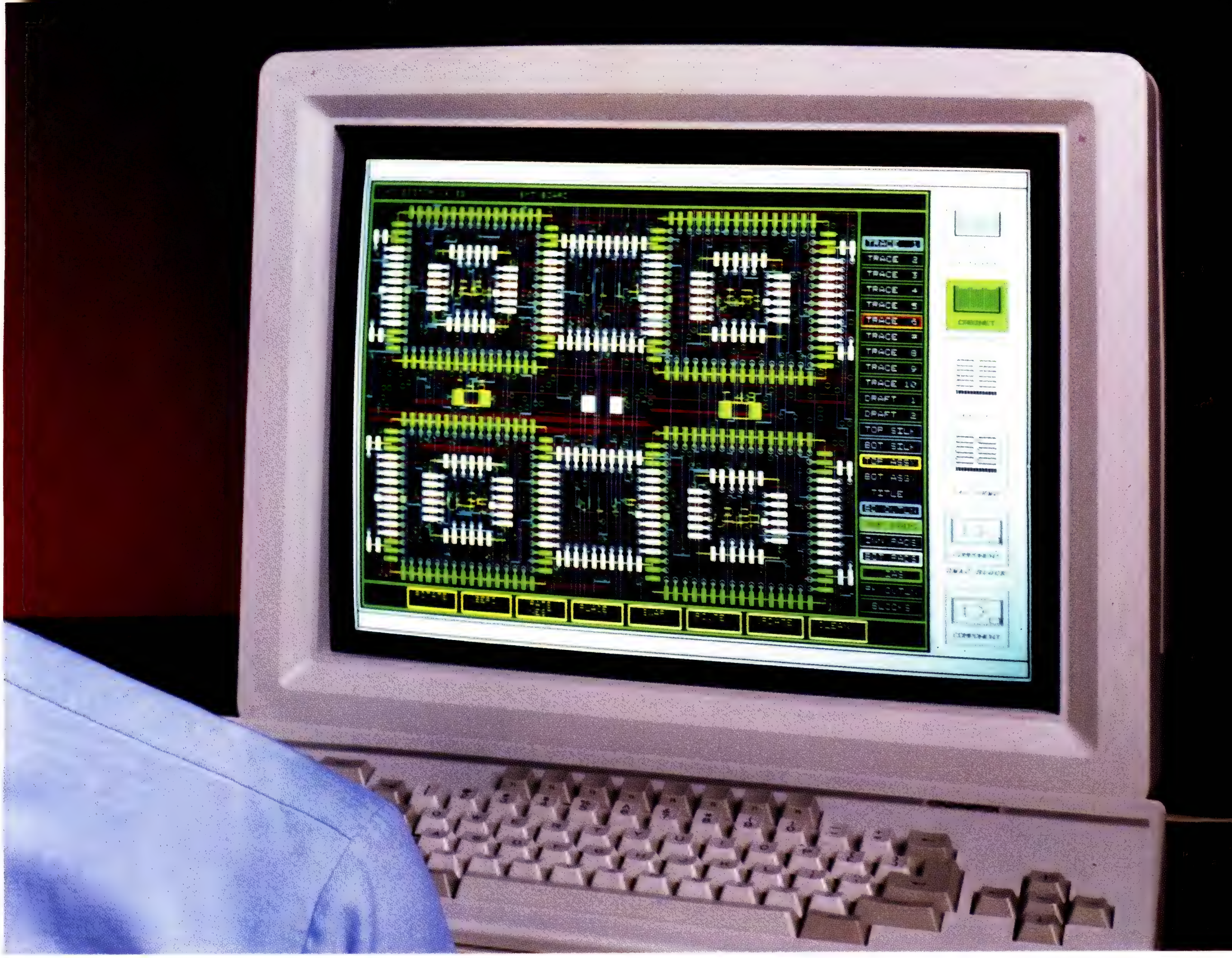

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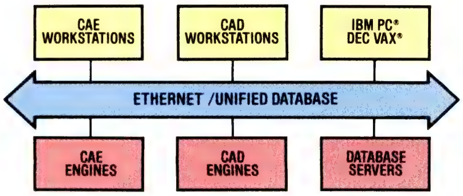

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Universal switched-capacitor filter lowers part count

Conventional RC filters often require manual tuning. In contrast, switched-capacitor filter ICs take advantage of carefully controlled semiconductor processes to deliver tight tolerances without hand tuning; they're suitable for a variety of voice- and data-communications applications.

Kerry Lacanette, *National Semiconductor Corp*

Universal switched-capacitor filters are versatile devices that furnish high center-frequency accuracy (1% tolerance) and require fewer components than comparable RCL filters. Using one such device (the MF8 switched-capacitor filter IC) and three external resistors, you can realize virtually any fourth-order, all-pole bandpass response (you can implement Butterworth or Chebyshev functions, for example) and control the amount of ripple as well.

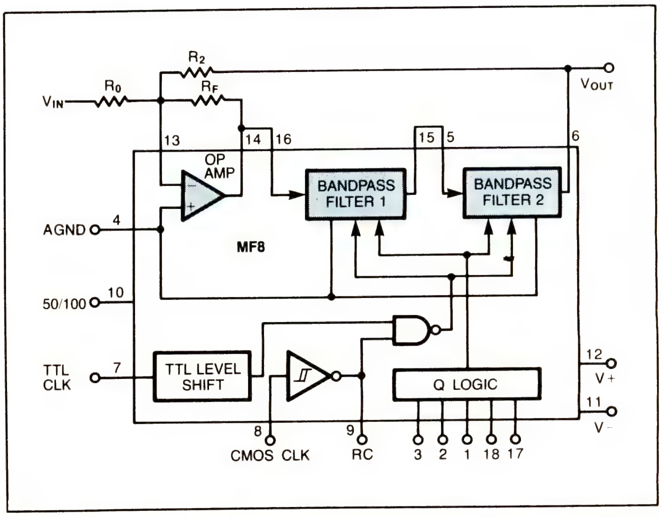

Fig 1—The MF8 switched-capacitor bandpass filter *needs three external resistors to set the gain, response characteristic, and input impedance. Logic levels on the five Q-logic pins set the bandwidth; the filter's center frequency equals the clock frequency divided by 50 or 100.*

Logic sets quality factor

The MF8's basic circuit configuration **(Fig 1)** needs only three external resistors to set the gain and response characteristic. To set the bandwidth, you apply the appropriate logic signals to the chip's quality-factor (Q-logic) pins. You can select from among 31 Q values ranging from 0.5 to 90. The filter's center frequency equals the clock frequency divided by either 50 or 100, depending on the state of the 50/100 pin (pin 10).

You can set the center of the passband anywhere from 0.1 Hz to 20 kHz. The chip will operate from single-ended or split supplies ranging from 8V (±4V) to 14V (±7V).

Switched-capacitor filters boast a center-frequency accuracy with 1% tolerance.

TABLE 1—FILTER PARAMETERS

RESPONSE	RIPPLE(dB)	K_Q	R_0/R_F	R_2/R_F
BUTTERWORTH	3.0	1.4142	2.0000	4.0000
CHEBYSHEV	0.01	0.4491	1.9025	3.6281
CHEBYSHEV	0.05	0.6919	1.7873	3.2311
CHEBYSHEV	0.1	0.8429	1.6999	2.9561
CHEBYSHEV	0.2	1.0384	1.5743	2.5962
CHEBYSHEV	0.4	1.2990	1.4071	2.1707
CHEBYSHEV	0.5	1.4029	1.3404	2.0160
CHEBYSHEV	0.8	1.6685	1.1789	1.6716
CHEBYSHEV	1.0	1.8220	1.0929	1.5038
CHEBYSHEV	1.25	2.0000	1.0000	1.3333
CHEBYSHEV	1.5	2.1685	0.9192	1.1935
CHEBYSHEV	1.75	2.3305	0.8479	1.0760
CHEBYSHEV	2.0	2.4895	0.7846	0.9760
CHEBYSHEV	2.5	2.7964	0.6775	0.8156
CHEBYSHEV	3.0	3.1037	0.5871	0.6881

You begin the design of your fourth-order bandpass filters by defining the filter's performance parameters: the center frequency (f_0), the bandwidth (BW), and the response characteristic (for instance, Chebyshev with 0.5-dB ripple). Next, you choose a reasonable value for R_F (for example, 20 kΩ). Then you look in **Table 1** for the values of the ratios R_2/R_F and R_0/R_F. Next you multiply the ratios by R_F to find the values for R_2 and R_0. These resistors set the filter's basic response characteristic. If you need a gain other than 1, divide R_0 by the desired gain and use the reduced value for R_0.

To set the filter's bandwidth, you must multiply the appropriate K_Q term in **Table 1** by your desired value of f_0/BW. Then you match that result with its corresponding entry in the Q_0 column of **Table 2** to determine the necessary inputs to the chip's Q logic. Finally, to set the filter's center frequency, you derive a clock signal with its frequency equal to 50 or 100 times the desired center frequency. The voltage on the 50/100 pin sets the clock's division ratio. If the pin is at V^+, the ratio will be 100:1; if the pin is at ground, the ratio will be 50:1.

Self-clocked operation is possible

The chip has two clock inputs, one for CMOS logic levels (pin 8), and one for TTL levels (pin 7). If you use a TTL clock, you must connect the CMOS clock pin to V^- (or to ground in single-supply applications). You can use a TTL clock with either a single supply or a bipolar supply, because the TTL input actually has two logic thresholds. One is referred to the analog-ground terminal, and the other is referred to the negative-supply terminal. The chip accommodates CMOS clock inputs at pin 8 if you connect the TTL input to V^+ or V^-. You should leave pin 9 (RC) open unless the chip is self-clocked. In that case, you connect a resistor between pins 8 and 9 and connect a capacitor between pin 8 and ground.

If you need a higher-order filter, you can cascade two

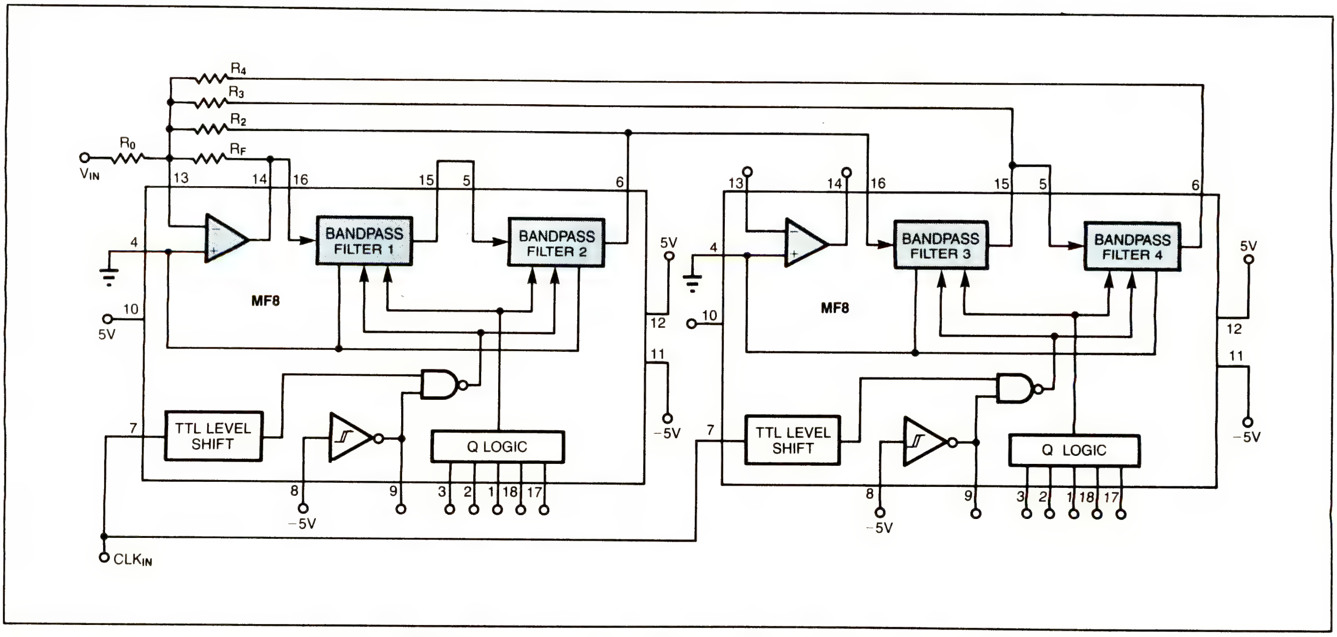

Fig 2—You can cascade two MF8s to build an eighth-order, multiple-feedback bandpass filter. The concept extends to higher-order filters.

or more chips to realize sixth-, eighth-, tenth-, or twelfth-order bandpass filters. Every pair of added poles requires an additional resistor. **Fig 2** shows an eighth-order bandpass filter using two MF8s and five external resistors. The design approach is the same as that of the fourth-order version, except that it contains more resistors. **Table 3** shows the pertinent resistor ratios for eighth-order filters.

Along with low center-frequency error, an important attribute of switched-capacitor filters is the ease with which you can change the center frequency. You simply vary the clock frequency (f_{CLK}). Because digitally programmable clocks with crystal-controlled accuracy are relatively easy to build from standard components, a single switched-capacitor filter can effectively act as a bank of precision filters operating at different frequencies. **Fig 3** shows an application of this concept.

The circuit includes a pseudorandom noise generator

TABLE 2—Q-LOGIC FACTORS

PIN					Q_0
17	18	1	2	3	
0	0	0	0	1	0.0
0	0	0	1	1	0.75
0	0	0	1	0	1.0
0	0	1	0	1	2.0
0	0	1	0	0	2.5
0	0	1	1	0	3.0
0	0	1	1	1	4.0
0	1	0	1	0	5.0
0	1	0	0	1	5.7
0	1	1	0	1	6.4
0	1	0	0	0	7.0
0	1	1	1	1	8.5
0	1	1	0	0	10.0
1	0	0	1	1	11.8
0	1	0	1	1	12.5
1	0	1	1	1	13.6
1	0	0	1	0	14.7
1	1	0	0	1	15.8
1	0	1	0	1	16.5
0	1	1	1	0	17.0
1	0	0	0	1	19.0
1	1	1	0	1	22.0
1	1	0	1	1	27.0
1	1	1	1	1	30.0
1	0	1	0	0	33.0
1	1	0	1	0	40.5
1	1	1	0	0	44.0
1	0	0	0	0	57.0
1	0	1	1	0	68.0
1	1	0	0	0	79.0
1	1	1	1	0	90.0

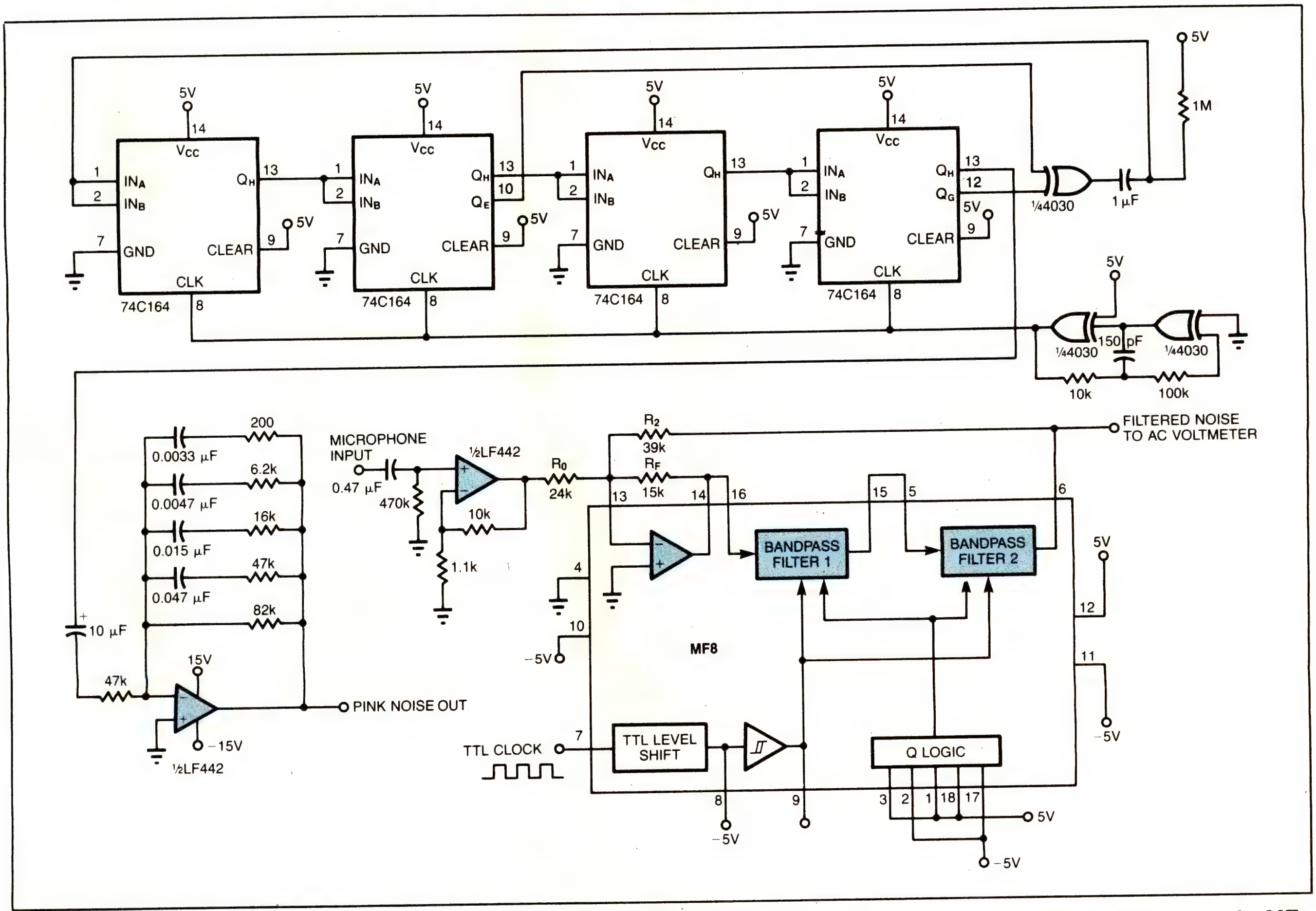

*Fig 3—**This pink-noise generator** with tunable bandpass filter proves useful for acoustic measurements. Because you can tune the MF8 simply by varying the clock frequency, it serves as a bank of precision bandpass filters as well.*

Switched-capacitor filter ICs require no external reactive components.

comprising four 74C164 shift registers and an exclusive-OR gate that provides a test signal for acoustic measurements. The noise circuit's output is essentially white noise (it has a constant spectral density) throughout the audio spectrum. Two other exclusive-OR gates configured as an oscillator generate the clock waveform for the noise generator.

The LF442 op-amp circuit filters the white noise to provide a more useful test signal. The LF442 circuit's output has a 3-dB/octave rolloff rate from 20 Hz to 20 kHz, so that the noise at its output has constant spectral density per octave of frequency (ie, the output is pink noise). The accuracy of the pink-noise filter is better than ±0.5 dB throughout the audio-frequency

Switched capacitors unlock filters

One of the two keys to the operation of switched-capacitor filters is the excellent matching of MOS capacitors that's possible on an integrated-circuit die. By paying careful attention to device geometries, chip makers can build onboard capacitors whose ratios (not absolute values) to each other are accurately controlled. Furthermore, these capacitor ratios remain constant even when their absolute values change because of variations in the ambient temperature.

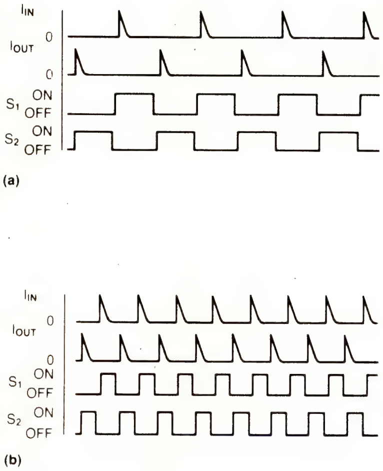

***Fig B—The average amount of current flowing out** of the switched-capacitor circuit depends on the switches' commutation rate.*

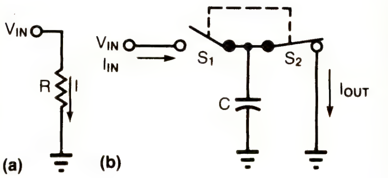

***Fig A—A capacitor-switch circuit (a)** replaces the real resistor **(b)** in a switched-capacitor filter—one of the keys to the circuit's operation.*

Switch replaces resistor

The other key to the operation of switched-capacitor filters is the ability of a capacitor and a couple of MOS switches to mimic the behavior of a resistor. To see how this mimicking might be done, look at **Fig Aa,** which shows a resistor connected to a source voltage on one side and to ground on the other side. If the source voltage is V_{IN}, and the resistance is R, obviously a current,

$$1 = \frac{V_{IN}}{R},$$

will flow through the resistor.

Now take a look at the circuit shown in **Fig Ab.** Capacitor C alternately connects, through switches S_1 and S_2, to the input voltage and to ground. When S_1 closes and S_2 opens, the capacitor will charge to V_{IN}. The total charge on the capacitor will be

$$Q = V_{IN}\,C.$$

When S_1 subsequently opens and S_2 closes, the charge (Q) will flow to ground through S_2. **Fig B** shows the current flowing into and out of the capacitor as a function of time. Note that this current consists of a quick burst at each switch closing. The amplitude and the duration of each current burst depends on whether there is any parasitic resistance in the switches (MOS transitors in the case of an IC implementation). If the switches' toggle rate increases, more bursts per unit of time will occur, as **Fig Bb** shows.

Net current

If I_{IN} is the average current into the network of **Fig Ab** and T is the time period between closings of S_1, the following equation expresses the result:

$$I_{AVG} = \frac{Q}{T} = \frac{V_{IN}\,C}{T}.$$

You can rearrange this equation to give an expression for the equivalent resistance of the circuit:

range. More complex networks can achieve even better accuracy, but audio measurements rarely need it.

The filter of **Fig 3**'s circuit has a fourth-order Chebyshev response with 0.2-dB ripple and a bandwidth equal to one-sixth of the center frequency. Pin 10 is grounded, so the center frequency will equal $f_{CLK}/50$. By varying the clock frequency, you can determine the

TABLE 3—EIGHTH-ORDER FILTER PARAMETERS

RESPONSE	RIPPLE (dB)	K_Q	R_0/R_F	R_2/R_F	R_3/R_F	R_4/R_F
BUTTERWORTH	3.0	1.5307	2.9146	2.000		
CHEBYSHEV	0.01	1.4257	1.4857	.9919	5.8275	14.306
CHEBYSHEV	0.05	1.9175	1.0129	46	2.1211	5.0403
CHEBYSHEV	0.1	2.2176	0.7986	0.5	1.883	2.8612
CHEBYSHEV	0.2	2.6097	0.5891	0.455	1.4954	.0342
CHEBYSHEV	0.4	3.1299	0.3956	0.3391	1.1250	0.
CHEBYSHEV	0.5	3.3406	0.3389	0.3040	.0114	0.6365
CHEBYSHEV	0.8	3.8811	0.2314	0.2344	846	0.3913
CHEBYSHEV	1.0	4.1981	0.1869	0.2038	0.9	0.3002
CHEBYSHEV	1.5	4.9172	0.1183	0.1528	0.514	0.1730
CHEBYSHEV	2.0	5.5849	0.07992	0.1588	0.4072	0.1093
CHEBYSHEV	2.5	6.2331	0.05610	0.09792	0.3315	0.7299
CHEBYSHEV	3.0	6.8778	0.04040	0.08113	0.2751	0.5053

$$R = \frac{V_{IN}}{I_{AVG}} = \frac{T}{C}.$$

Note that the equivalent resistance depends on only two quantities: the capacitance (C) and the switching rate. Because the switching rate derives from an externally applied, adjustable clock, the result is a clock-variable resistor. You can extend this concept easily to the integrator circuit shown in **Fig Ca.** This circuit is the basis of numerous active-filter designs. It is easy to see how to replace the input resistor with a switched-capacitor resistor. This replacement yields an integrator with no resistors, as shown in **Fig Cb.** The time constant of the integrator is simply

$$t = \frac{T\,C_2}{C_1}.$$

Note that the time constant doesn't depend on the absolute accuracy of the capacitors, only on their ratio. Because IC makers can fabricate IC capacitors with very accurate ratios, the filter's time constant will also be very accurate.

Fig D shows a couple of variations on the simple switched-capacitor integrator. The first is a noninverting integrator. In this circuit, S_{1A} and S_{1B} close simultaneously to charge C_1 to the input voltage (V_{IN}). S_{1A} and S_{1B} then open, and S_{2A} and S_{2B} close, connecting C_1 to the summing junction, but with the capacitor's polarity reversed. The reversal effectively inverts the inverter, resulting in a noninverting integrator. A positive V_{IN} will now result in an output voltage that moves in the positive direction.

A useful variation on the noninverting circuit **(Fig Db)** connects S_{1B} to a second input signal V_{IN2} instead of ground to create a differential integrator. The output voltage is now the integral of ($V_{IN1}-V_{IN2}$).

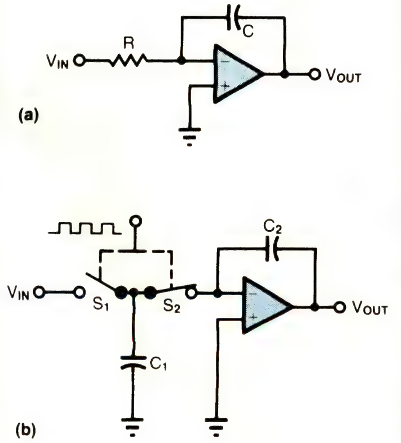

*Fig C—**The switched-capacitor circuit can substitute** for the input resistor of an inverting integrator.*

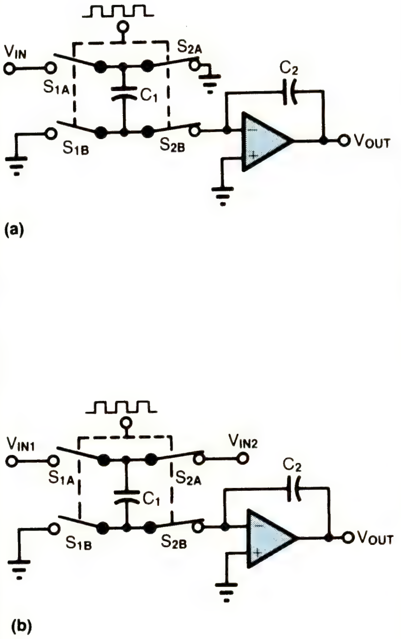

*Fig D—**Adding two switches** to an inverting switched-capacitor integrator results in a noninverting version of the circuit **(a)**. In addition, a simple modification yields a differential switched-capacitor integrator **(b)**.*

> *Designing a fourth-order bandpass filter begins with defining the filter's performance parameters.*

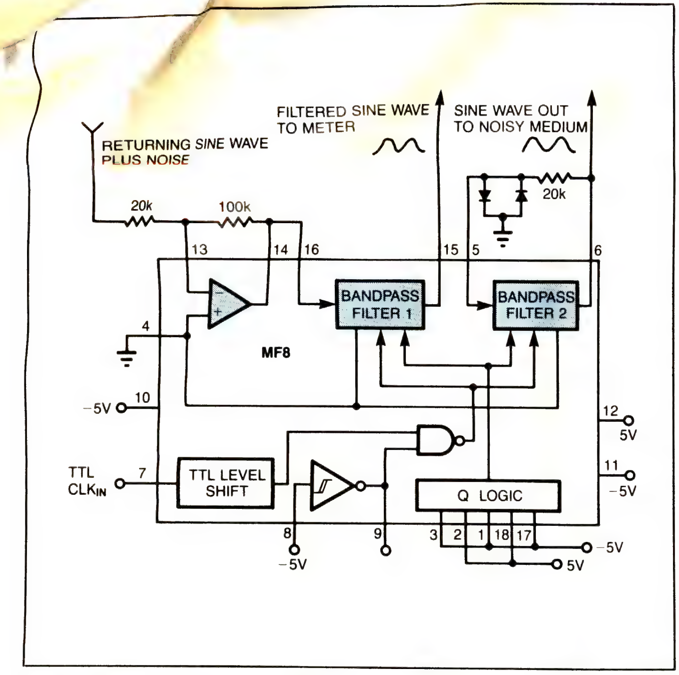

Fig 4—With its clock-tunable sine-wave generator *and tracking noise-rejection filter, this circuit is useful when measuring the transmission of a signal through a noisy medium. The sine-wave generator is far simpler than triangle-to-sine approaches that use differential transistor pairs or piecewise-linear approximation.*

system under test's response as a function of frequency. Much simpler versions of the same circuit, without the random noise generator, prove useful in measuring environmental noise in various frequency ranges with much better resolution than simple handheld meters with A-weighted response characteristics.

Filter out noise

The circuit shown in **Fig 4** proves useful in numerous applications calling for the measurement of signals at specific frequencies in the presence of noise. The circuit operates over the 0.1-Hz to 20-kHz frequency range. Instead of a pseudorandom noise generator, the circuit uses one of the MF8's filter blocks as a sine-wave oscillator to generate test signals. The sine-wave generator's output regeneratively feeds back to its input, where two diodes clip the signal. After filtering, the clipped waveform yields a sine wave whose frequency is equal to $f_{CLK}/50$.

Because of its low part count and lack of external adjustments, this circuit is an attractive alternative to other wide-frequency-range, sine-approximation circuits that use differential-transistor pairs or piecewise-linear op-amp circuits to shape triangle waves into near sinusoids.

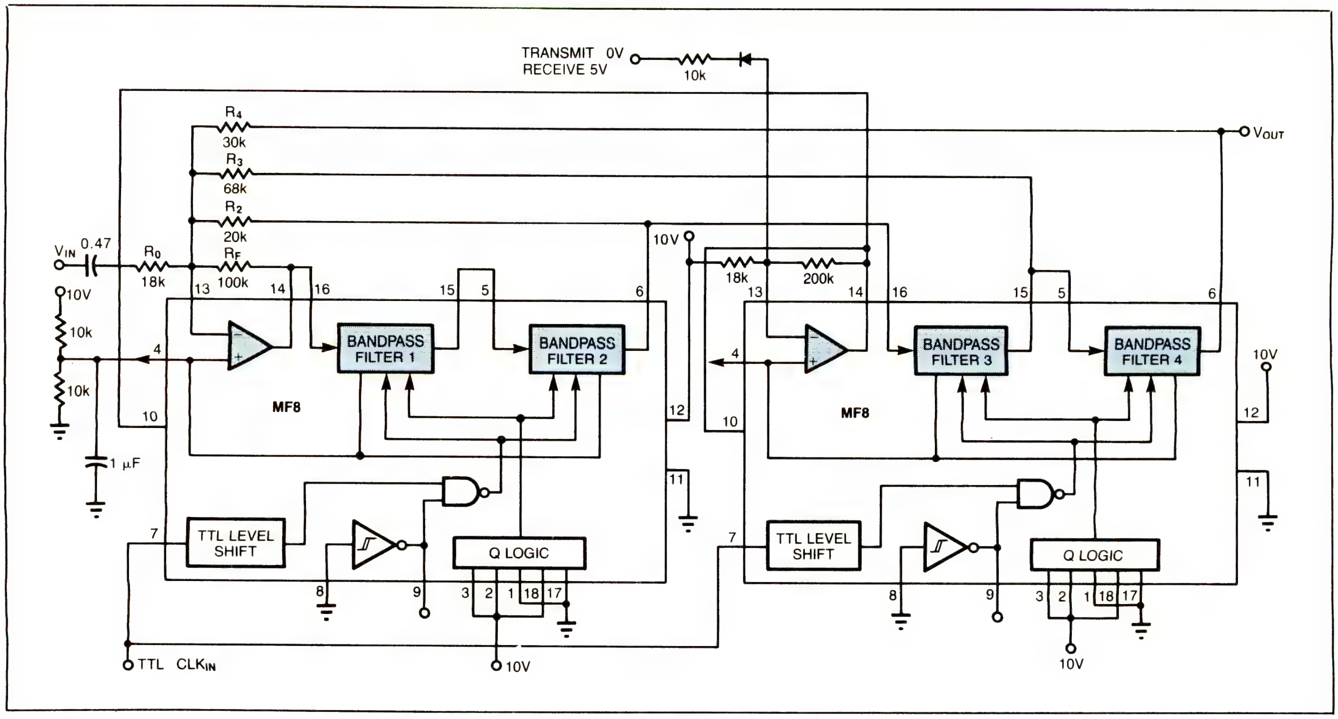

Fig 5—This eighth-order modem filter provides 50-dB attenuation *of out-of-band signals. You switch it between the transmit and receive modes by changing the clock-division ratio from 50:1 to 100:1.*

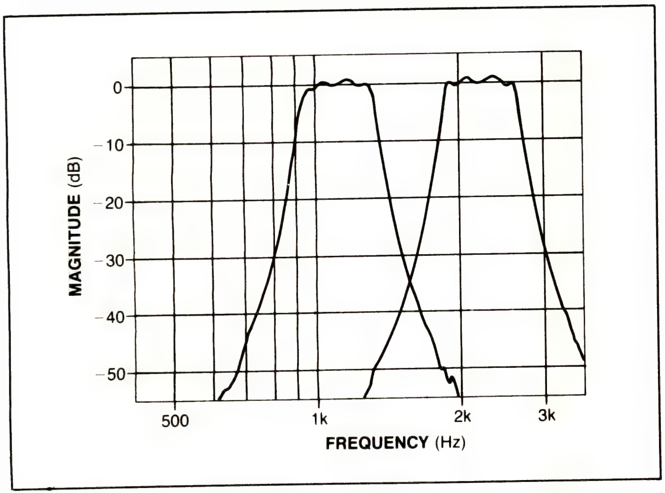

***Fig 6—The graph shows the response curves** for the modem filter of **Fig 5**. Note that the filter response remains the same as the center frequency varies.*

Because the center frequency of the MF8's remaining bandpass-filter stage is the same as the sine generator's output frequency, the filter can track the test signal, rejecting any potentially disruptive out-of-band signals. The MF8's operational amplifier provides gain to the returning signal; **Fig 4**'s circuit has a return gain of 10, including the filter gain.

Fig 5 shows two MF8s in a modem transmit/receive circuit operating from a single 10V power supply. A TTL signal changes the clock/center-frequency ratio from 100:1 to 50:1, thereby switching the circuit from the transmit mode to the receive mode. The 110-kHz TTL clock signal sets the center frequencies of the two possible bandpass responses to either 1.1 kHz or 2.2 kHz. The filter has an eighth-order Chebyshev-response characteristic with 1-dB passband ripple. Its bandwidth is equal to about one-third of the center frequency.

Circuit puts second op amp to work

The op amp in the second MF8 converts the TTL transmit/receive selection signal to a 0 to 10V logic level compatible with the 50/100 control input at pin 10 of each IC. This application is a rather unconventional use of the 50/100 input; normally you just hard-wire the input to V^+ or V^-. Similarly, the Q-logic pins are typically hard-wired high or low for any given application. In addition, their logic thresholds are approximately 5V and are incompatible with TTL drive signals. Therefore, in specialized applications requiring TTL control of Q or the clock-to-center-frequency ratio, the simplest solution is to connect a standard level translator, such as a DA78L12, to convert the TTL levels to signals the Q-logic and 50/100 pins can use.

The Bell 103 standard calls for transmit tones (mark and space) at 1070 Hz and 1270 Hz and receive tones at 2025 Hz and 2225 Hz for the originating modem. An eighth-order Chebyshev filter with 1-dB ripple, an 1100-Hz center frequency, and a bandwith equal to one-third the center frequency will provide at least 50-dB attenuation of the nearest out-of-band signal tones. When using 5% resistors, the response curve shown in **Fig 6** results.

Some changes for single-ended power

Operation from a single-ended power supply requires only a few obvious changes from the circuit's split-supply connection: V^- becomes ground, and a pair of resistors and a capacitor bias the AGND pin (pin 4) to half the supply's level. Because of the MF8's dual-TTL thresholds, the TTL clock signal is still referred to ground.

The simple tone-detector circuit shown in **Fig 7** uses the MF8's two internal bandpass sections in a cascade, without any overall feedback. Total gain at the center frequency is 4, and the Q of each section is 5. The filter's output goes to a diode-capacitor peak detector, which in turn drives the resistive divider at the input to the op amp. When the voltage on the capacitor is between

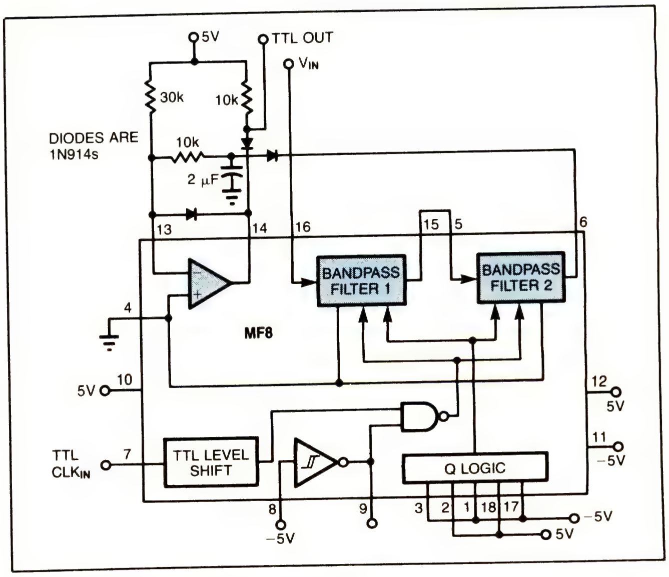

***Fig 7—Two bandpass filters** drive a peak-detector/comparator that gives a 5V output when the center frequency's amplitude is above approximately 300 mV.*

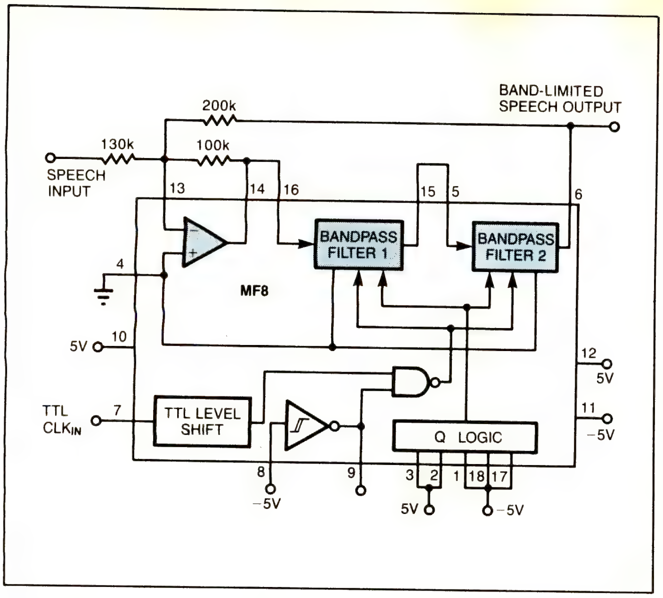

*Fig 8—**This speech-range band-limiting filter** for voice-communications systems reduces transmission-power requirements without affecting intelligibility.*

about −1.7 and 0V, the amplifier operates in closed-loop fashion, and its output voltage is a diode drop below ground, resulting in 0V at the circuit's TTL output. When the in-band input-signal level reaches about 1.2V rms, the op amp operates in open-loop fashion, and the TTL output goes to 5V. When the clock frequency is 500 kHz (as shown), the circuit detects 5-kHz signal tones.

Limiting the speech-signal band to a frequency range of approximately 500 Hz to 3 kHz often improves the performance of voice-communication systems. This lim-

Filter IC adapts to applications

The block diagram in **Fig 1** on pg 139 shows the MF8's basic architecture. The IC's internal analog circuitry comprises two identical second-order bandpass filters and an operational amplifier. The op amp is a CMOS device with a 10-pA input bias current and an 80-dB open-loop gain at dc. The amplifier's gain-bandwidth product is 1.8 MHz, and its slew rate is 10V/μsec. The noninverting input ties internally to the analog ground pin (A_{GND}), so the op amp functions only in the inverting mode.

Fig A shows a simplified schematic of the chip's second-order filter circuits. The resistors in the diagram are actually capacitors and MOS switches. The integrators in the MF8 are inverting types. Therefore, the chip's bandpass-filter sections use inverting feedback resistors. These unconventional circuit elements are easy to build in switched-capacitor form. The ratio R_B/R_N determines the filter's quality factor (Q); you can therefore adjust Q without affecting the gain or the center frequency when you vary the value of R_N.

R_N is in reality a switched-capacitor resistor, and **Fig B** shows how you adjust its value by connecting capacitors in parallel with CMOS switches. You adjust R_{IN} and R_B in a similar manner to provide even more values of Q while holding the gain constant. The chip decodes the logic signals on the five Q-set pins to determine which of these switches will be open and which will be closed, thereby determining the total capacitance.

To understand the multiple feedback-loop filter, first examine the circuit shown in **Fig C.** The circuit comprises an operational amplifier, two identical second-order bandpass filters, and four resistors. If you define the two filter blocks in terms of their gain, center frequency, and Q (H_0, ω_0, and Q_0, respectively), their transfer functions are

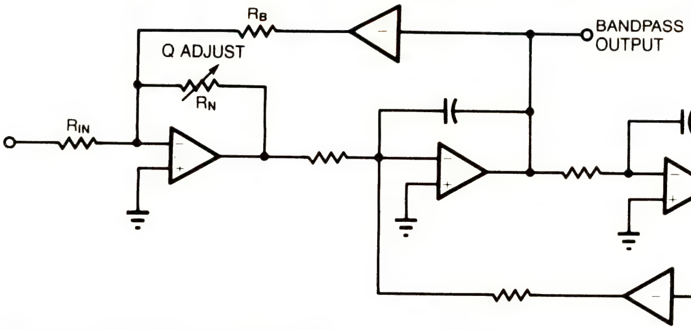

*Fig A—**Each second-order bandpass block within the MF8** uses integrating invertors. Because of the inverting integrators, the filters require inverting, switched-capacitor resistors.*

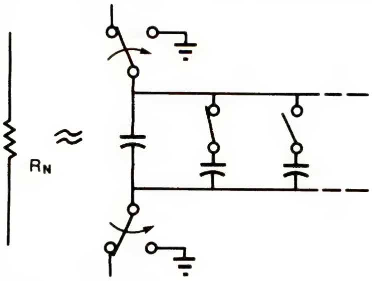

*Fig B—**R_N, which controls the filter's quality factor,** actually comprises switches and a capacitor whose value you change by adding additional parallel capacitors. The chip's Q logic controls the switches.*

The filter IC operates from both single and bipolar supplies and accepts either CMOS or TTL clock signals.

iting has little effect on intelligibility, but it produces a significant savings in the amount of speech power transmitted. In addition, similar filtering after reception improves the S/N ratio, and therefore the intelligibility of speech signals. The circuit shown in **Fig 8** realizes this band-limiting function in a fourth-order Chebyshev bandpass filter with 0.5-dB ripple. **EDN**

Article Interest Quotient (Circle One)
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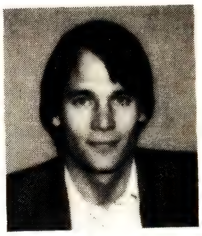
Author's biography



Kerry Lacanette is a MOS/analog applications manager at National Semiconductor (Santa Clara, CA), where he works on the development of data-acquisition ICs, switched-capacitor filters, and other analog circuits. He has been with the company for eight years. Kerry received his BSEE and MSEE degrees from the University of California, and he is a member of the AES.

$$T_1 = T_2 = \frac{H_0 \dfrac{\omega_0}{Q_0} s}{s^2 + \dfrac{\omega_0}{Q_0} s + \omega_0^2}.$$

When you connect the two bandpass filters, op amp, and resistor as shown, a fourth-order bandpass filter results. Analysis of the fourth-order filter's transfer function shows that you can omit R_1 from the circuit with no loss of flexibility, leaving three resistors: R_0, R_2, and R_F. These resistors, the clock frequency, and the Q of the second-order bandpass sections define the filter's overall response.

A standard approach to fourth-order bandpass-filter design first involves the development of a second-order, lowpass prototype whose transfer function is

$$G_{LP}(s) = \frac{-Hb_0}{s^2 + sb_1 + b_0},$$

where H is the passband gain, and b_0 and b_1 determine the behavior of the lowpass response. You can find tables of these coefficients in filter-design texts. As an example, the values $b_0=1$ and $b_1=\sqrt{2}$ specify a Butterworth lowpass filter with its cutoff at 1 radian/sec. The following equations relate the fourth-order bandpass filter to the second-order prototype:

$$Q_0 = \frac{f_0}{BW} \times \frac{2}{b_1}, \quad (1)$$

$$\frac{R_0}{R_F} = \frac{b_1^2}{Hb_0}, \quad (2)$$

$$\frac{R_2}{R_F} = \frac{4}{\dfrac{4b_0}{b_1^2} - 1}. \quad (3)$$

The ratio R_F/R_0 determines the filter's gain, and R_2/R_F determines the general response characteristic (Butterworth, Chebyshev with 0.2-dB ripple, etc). The Q_0 value of the two second-order bandpass stages determines the bandwidth of the overall filter. You can adjust gain and bandwidth without changing the basic filter response. In other words, if a filter is a Chebyshev filter with 0.3-dB ripple, the response will exhibit the same 0.3-dB ripple regardless of the bandwidth. Using a filter-design reference, a table of second-order filter coefficients, a pocket calculator, and **Eqs 1, 2, and 3**, you can determine the necessary resistor and Q values for any desired fourth-order bandpass response. The calculations become less tedious if you use **Table 1** on pg 140.

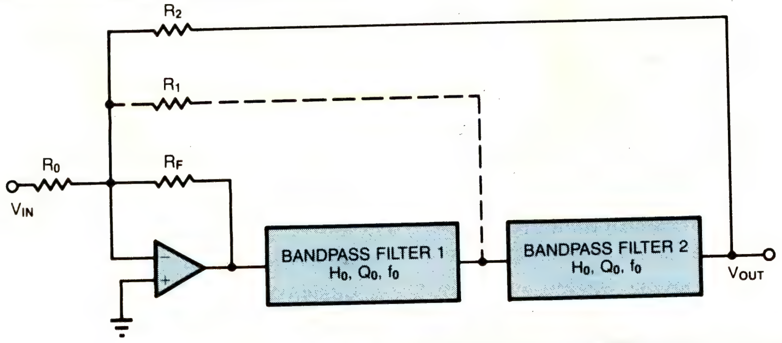


***Fig C—In the multiple-feedback configuration** of the switched-capacitor circuit, you can eliminate R_1 with no loss in flexibility.*

DDC NEWS

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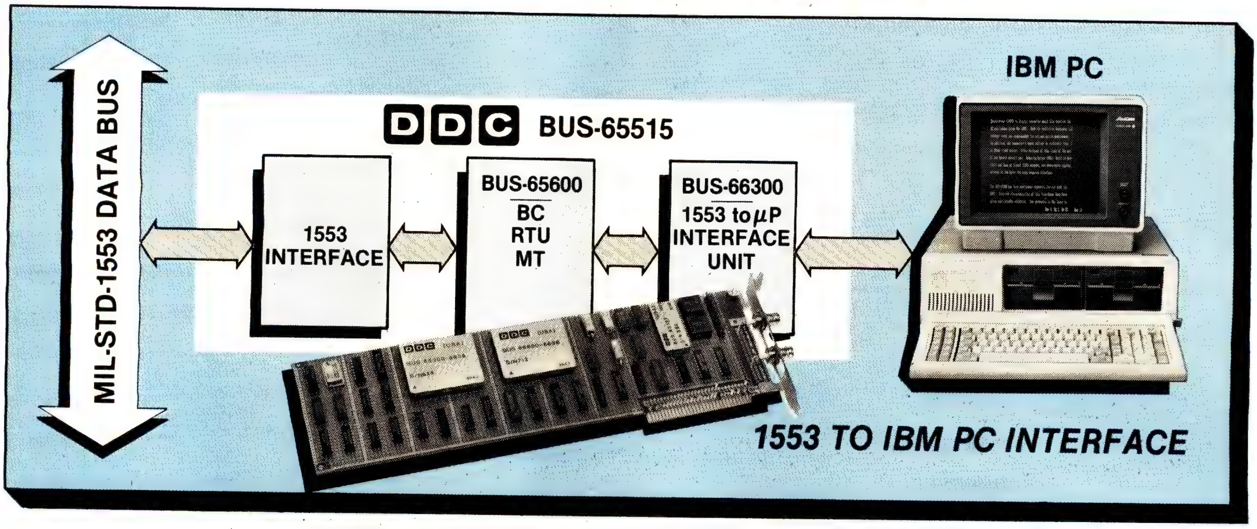

DDC has expanded its extensive line of MIL-STD-1553 BC/RTU/MT interface cards through the introduction of the new IBM PC to 1553 serial MUX bus interface card. Designated BUS-65515, it is packaged on a standard full size IBM PC printed circuit card, and offers complete, intelligent interfacing featuring transparent operation with a minimum of host processor intervention. The BUS-65515 is software configurable for use as a 1553 Bus Controller (BC), Remote Terminal Unit (RTU) or passive Bus Monitor Terminal (MT); supporting 12 mode codes, all 1553 message formats and complete wrap-around Built-In-Test (BIT).

The BUS-65515 interface board is composed almost entirely of DDC standard products including the BUS-65600 BC/RTU/MT full-function hybrid, BUS-66300 interface hybrid, BUS-63127 transceiver and the BUS-29854 transformer, along with a 12 MHz clock, 4K x 16 RAM, IBM PC I/O handling logic, address and data buffers and some additional interface "glue" logic.

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After subsystem initialization of the command registers and shared memory, management and control of the on-card RAM are performed without subsystem intervention. As a BC, the memory map contains data blocks, a data block descriptor stack and a stack pointer. As an RTU, the memory map contains data blocks, a descriptor stack, descriptor stack pointers and subaddress look-up tables.

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BVDSS	>10$_V$	>10$_V$
$K^1 = \frac{\mu c}{2}$ linear region	21–25	6.5–8.5
B_E(Long Channel)	0.8–1.2$_V^{1/2}$	0.4–0.6$_V^{1/2}$
Cap. Gate 10^4 PF/cm^2	8–10	8–10
Cap. Poly to Sub 10^4 PF/cm^2	0.55–0.65	0.55–0.65
Cap. Metal to Sub 10^4 PF/cm^2	0.27–0.32	0.27–0.32
Junction Depth	0.4μ–0.6μ	0.2μ–0.4μ
P-Well Junction	2.5μ–3.5μ	
Poly P_S	15–30Ω/☐	15–30Ω/☐
Diffusion P_S	20–40Ω/☐	60–100Ω/☐
VTF Poly	>10$_V$	>10$_V$
ΔW	—1.0μ	—1.2μ
LEFF	1.0μ–1.4μ	1.3μ–1.7μ
Substrate Resistivity	2.5KΩ/☐	1.2Ω/cm

Feature Size: 3μ CMOS

	N-Channel	P-Channel
VTEO	0.5-1.0$_V$	0.5–1.0$_V$
BVDSS	>10$_V$	>10$_V$
$K^1 = \frac{\mu c}{2}$ linear region	18–21	6–8
B_E(Long Channel)	0.8–1.4$_V^{1/2}$	0.4–0.6$_V^{1/2}$
Cap. Gate 10^4 PF/cm^2	5.9–7.0	5.9– 7.0
Cap. Poly to Sub 10^4 PF/cm^2	0.45–0.55	0.45–0.55
Cap. Metal to Sub 10^4 PF/cm^2	0.2–0.25	0.2–0.25
Junction Depth	0.6μ–1.0μ	0.4μ–0.8μ
P-Well Junction	3.5μ–4.5μ	
Poly P_S	15–30Ω/☐	15–30Ω/☐
Diffusion P_S	10–30Ω/☐	30–70Ω/☐
VTF Poly	>10$_V$	>10$_V$
ΔW	—1.0μ	—1.0μ
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The microcontrollers that incorporate the Signetics/Philips I^2C bus are the company's SCN 8400 (equivalent to the MAB 8400) and PCD 3343 ICs. The I^2C peripheral controllers are the company's Clips family of devices, which includes LCD/LED drivers, RAM, ROM, real-time clocks and timers, A/D and D/A converters, DTMF generators, tuning circuits for computer-controlled television sets, and speech-synthesis ICs (**Table 1**). The maximum allowable bus capacitance of 400 pF limits the distance between system components to a few feet and limits clock speed to the 0.7- to 114-kHz range.

TABLE 1—ICs INCORPORATING THE I^2C BUS

PCF 3311/12	DTMF GENERATOR
PCF 8570	256-BYTE STATIC RAM
PCF 8571	128-BYTE STATIC RAM
PCB 8573	CLOCK/CALENDAR
PCF 8574	8-BIT REMOTE I/O EXPANDER
PCF 8576	MULTIPLEXED LCD DISPLAY DRIVER
PCF 8577	DUPLEX LCD DISPLAY DRIVER
PCF 8591	8-BIT, 4-CHANNEL A/D CONVERTER
PCF 8592	EEPROM
SAA 1063	FLUORESCENT DISPLAY DRIVER
SAA 1300	SWITCHING CIRCUIT
SAA 3028	INFRARED RED TRANSCODER
SAA 3035/36/37	FREQUENCY LOCKED-LOOP TUNING CIRCUIT
SAA 5240	TELETEXT CONTROLLER CHIP
PCF 8200	SPEECH SYNTHESIZER
TEA 6000	FM/IF SYSTEM
TDA 8442	FOUR 6-BIT D/A CONVERTERS
MAB 8400 FAMILY	8-BIT MICROCONTROLLER (NMOS)
PCD 3343	8-BIT MICROCONTROLLER (CMOS)
PCF 8572	128-BYTE EEPROM
PCF 8582	256-BYTE EEPROM
TEA 6300	ACTIVE TONE CONTROL

The I^2C hardware interface controls all bus activity; it constantly monitors bus-free/bus-busy conditions, bus contention, slave acknowledgment, and bus interference. These facilities, together with the simplicity of the interconnections, tend to reduce the size and pin count of the ICs that use the structure, and make an I^2C

You can easily expand an I^2C system by adding peripherals, and you can put more than one master on the same bus.

system simple to design. You can easily expand such a system by adding peripherals, and you can put more than one master on the same bus. **Fig 1** shows a typical I^2C bus configuration.

To program the I^2C microcomputers to control the various peripheral devices, you must first understand the I^2C serial bus protocol. The bus protocol is simple: A master initiates a data transfer by establishing a start condition, which is defined as a high-to-low transition on the data line while the clock line remains high. This transition indicates that an address/data stream will follow. All peripherals respond to the start condition and shift the next eight bits (which comprise a 7-bit address and a read/write control bit) into their S_0 registers. The slave that recognizes the transmitted address responds by pulling the data line low during a ninth clock pulse issued by the master; all other slaves withdraw from the bus at this point.

When it receives an acknowledgment of the address byte, the master transmits either a data stream or a subaddress followed by a data stream; the master expects an acknowledgment from the slave after every byte. The master then terminates the read or write operation with a stop condition (a low-to-high transition on the data line while the clock line is high). Such operations fall into one of four possible categories: writing to a slave that has only a device address; reading from a slave that has only a device address; writing to a slave that has a subaddress; and reading from a slave that has a subaddress.

Fig 2 shows the order of control and data information for each of the four categories. Slaves (such as the PCF 8570) that have both a device address (equivalent to chip enable) and a subaddress (equivalent to a word or register address) interpret the first byte as the device address, the second byte as the subaddress, and all following bytes as data. To avoid the necessity of transmitting a device address and subaddress for every byte, such slaves have autoincrementing data pointers that allow you to write data blocks of any length to (or read them from) a starting address in memory.

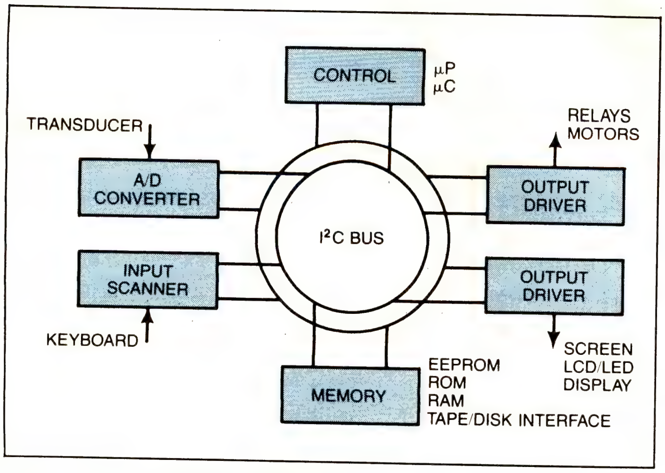


*Fig 1—**In this typical configuration,** a master controls several peripherals over the I^2C bus. You can add additional masters without introducing contention problems.*

Fig 2c illustrates the protocol by which a master reads from a device that has a subaddress. The master first transmits the 7-bit device address, followed by a write control bit, and receives an acknowledgment from the peripheral being addressed. The master then transmits the subaddress to the slave, and the slave stores the subaddress.

The master now prepares to read data: It sends a new start condition, the same 7-bit device address, and a read control bit. The slave then starts sending the master the data bytes. The master issues an acknowledgment after each byte except the last one and terminates the read operation with a stop condition. Note that the repeated start condition affects only the peripheral that recognized its own address; the other peripherals are quiescent and won't respond until a stop condition resets their interface hardware.

Microcontrollers with an I^2C bus interface, such as the SCN 8400 and PCD 3343, incorporate the bus protocol on chip. Implementing the protocol requires three registers and some supporting circuitry **(Fig 3)**. All serial address and data transfers take place between the µP accumulator and the shift register S_0. A byte to be sent serially is loaded in parallel from the µP's internal bus and shifted out to the SDA line, most significant bit (MSB) first. Similarly, a byte received serially on the SDA line is shifted into the S_0 register, MSB first. Other parts of the interface hardware recognize a start condition, generate shift clock pulses to shift the data into or out of the S_0 register, and generate an acknowledgment.

During the initialization of a slave, the µP enables address register S_0' and loads it with the address that the slave will recognize. The master doesn't normally enable this register. In a multiple-master system, however, a master may enable S_0' under software control so that other masters on the bus will treat it as a slave. The process of activating the S_0' register sets the AAS (Addressed As Slave) flag in status register S_1.

Bus control register S_1 performs several status and control functions. The upper four bits define the role of

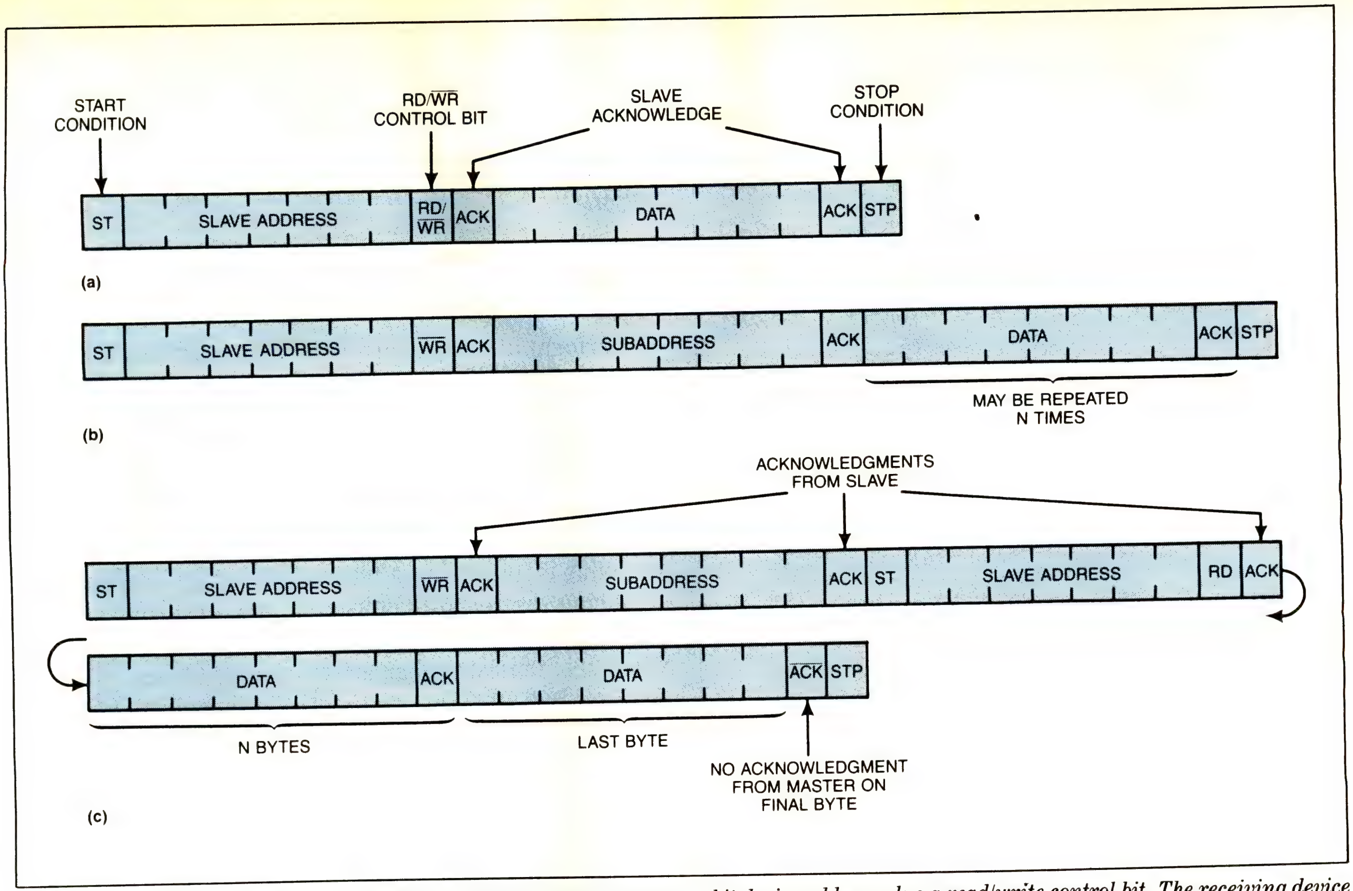


Fig 2—In the simple protocol *for the I^2C bus, the first byte is always a 7-bit device address plus a read/write control bit. The receiving device sends an acknowledgment after every byte. The sequence of operations for reading or writing data to a peripheral that has only a device address is shown in* ***a****. The sequence for writing to a peripheral that has both a device address and a subaddress is shown in* ***b,*** *and* ***c*** *indicates how the master reads from a peripheral that has both a device address and a subaddress.*

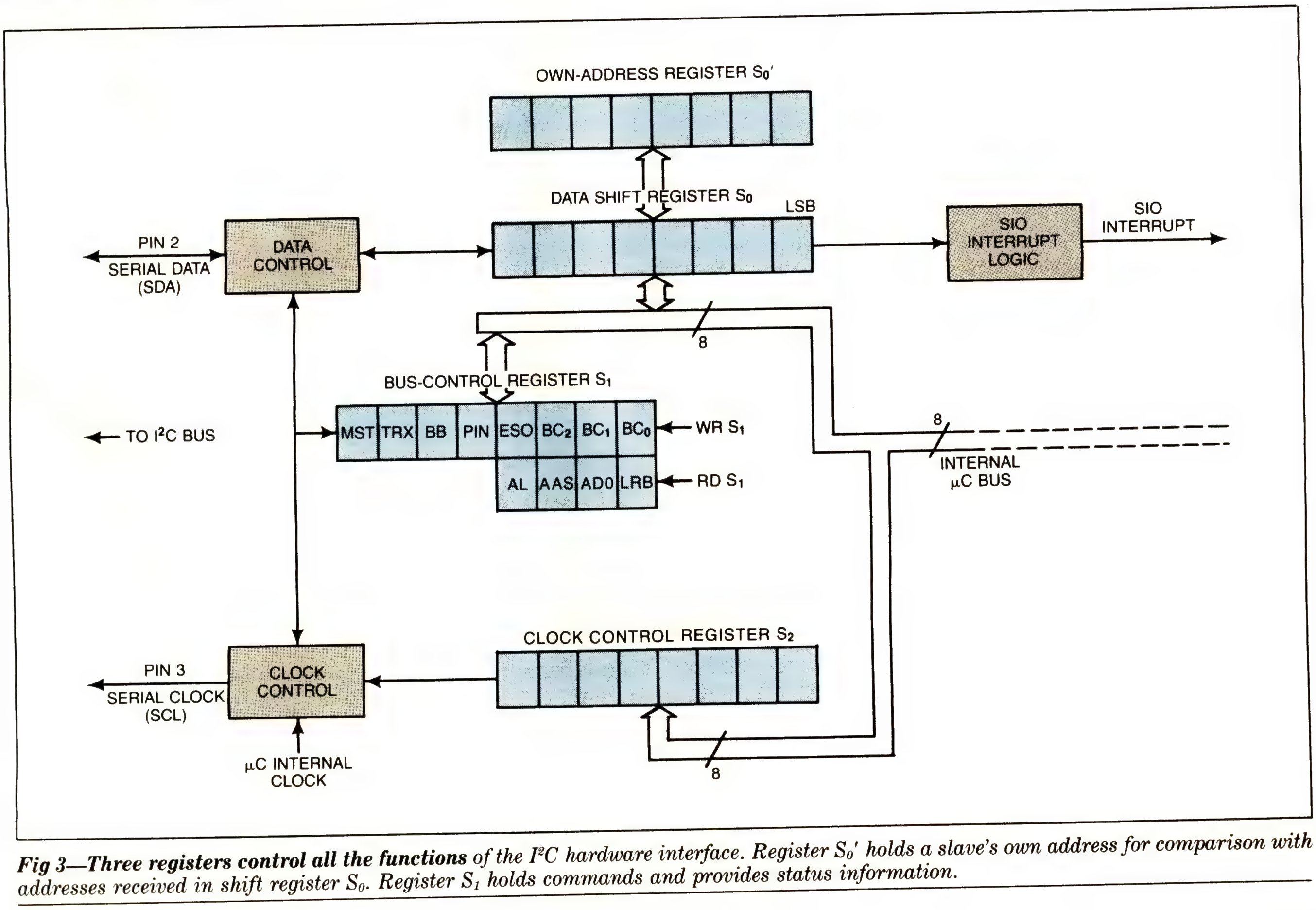


Fig 3—Three registers control all the functions *of the I^2C hardware interface. Register S_0' holds a slave's own address for comparison with addresses received in shift register S_0. Register S_1 holds commands and provides status information.*

TABLE 2—THE I^{2}C BUS SERIAL CLOCK FREQUENCY

HEX S20-S24 CODE	DIVISOR	APPROX f_{CLOCK} (kHz)
0	NOT ALLOWED	
1	39	114
2	45	98
3	51	87
4	63	70
5	75	59
6	87	51
7	99	45
8	123	36
9	147	30
A	171	26
B	195	23
C	243	18
D	291	15
E	339	13
F	387	11
10	483	9.2
11	579	7.7
12	675	6.6
13	771	5.8
14	963	4.6
15	1155	3.8
16	1347	3.3
17	1539	2.9
18*	1923	2.3
19*	2307	1.9
1A*	2691	1.7
1B*	3075	1.4
1C	3843	1.2
1D	4611	1.0
1E	5379	0.8
1F	6147	0.7

NOTE: ALL VALUES ARE FOR CLOCK-PULSE FREQUENCY CONTROL WHEN USING A 4.43-MHz CRYSTAL

*INDICATES THE ONLY VALUES THAT CAN BE USED IN THE LOW-SPEED MODE (ASC=1)

the controller at any given time. The MST (Master) bit defines the controller as either a master (which generates the serial clock on the SCL line) or as a slave (which does not). The TRX (Transmitter) bit defines the controller as a sender or as a receiver. The BB (Bus Busy) bit indicates whether or not the bus is in use: A start condition sets the BB bit, and a stop condition resets it. The active-low PIN (Pending Interrupt Not) bit is set by the start of a byte transfer and is reset upon transmission of the associated acknowledgment. The µP can poll this bit in order to detect completion of a transfer; alternatively, if the software has enabled the serial interrupt, an interrupt will transfer control to location 07H.

The lower four bits of register S_1 control the serial I/O or provide status information about the serial I/O.

For all I^{2}C devices, the interface between the microprocessor and the 2-wire bus consists of three registers and some supporting circuitry.

To perform an output operation, the µP sets the ESO (Enable Serial Output) bit and writes a 3-bit number into the counter bits ($BC_{2\text{-}0}$); this number determines how many bits will be sent to the serial data line. To send eight bits, you need to preload the counter with 000, and as each bit is sent, the counter is decremented by one. A ninth (acknowledge) bit is also sent, unless you omit it by setting a bit in clock-control register S_2.

During the serial I/O bus cycle, the lower four bits of register S_1 provide status information. The AL bit, when set, indicates that arbitration has been lost. The AAS bit indicates that the controller is being addressed as a slave. The AD0 bit is set when address zero (the general call) has been received, and the LRB bit indicates the status of the last received bit (which is usually polled to find the status of the acknowledge bit).

The five least significant bits (4 through 0) of clock/acknowledge control register S_2 determine the speed of serial bit clock SCL. The µP loads these bits under software control. The interface hardware applies the system-clock pulse to a frequency divider whose output is the serial-bit-clock pulse. The code in bits 4 through 0 of register S_2 determines the division ratio and the resulting serial-bit-clock frequency, as shown in **Table 2.** The software for a slave controller will set the bit clock to the frequency best suited to the controlled peripheral. A master, however, may change the bit-clock frequency as necessary to communicate with a variety of peripherals on the bus. When bit 6 of register S_2 is set to 1, an acknowledgment bit is generated. When bit 6 is reset to 0, acknowledgment generation is inhibited.

Except for some I^{2}C-specific instructions, the instruction set for the controllers is similar to the one for the Intel 8048 (**Table 3**). You can, therefore, use any standard 8048 assembler program, along with the macros listed in **Table 4**, to assemble programs for the SCN 8400 and PCD 3343 8-bit microcontrollers.

TABLE 3—COMPARISON OF THE INSTRUCTION SETS FOR THE SCN8048 AND SCN8400

SCN8400 FAMILY INSTRUCTIONS NOT IN THE SCN8048 INSTRUCTION SET

SERIAL I/O	REGISTER	CONTROL	CONDITIONAL BRANCH

MOV A,Sn
MOV Sn,A
MOV Sn,#data
EN SI
DIS SI
	DEC @Rr
	DJNZ @Rr,addr
		SEL MB2
		SEL MB3
			JNTF addr

SCN8048 INSTRUCTIONS NOT IN THE SCN8400 FAMILY INSTRUCTION SET

DATA MOVES	FLAGS	BRANCH	CONTROL

MOVX A,@R
MOVX @R,A
MOVP3 A,@A
MOVD A,P
MPVD P,A
ANLD P,A
ORLD P,A
	CLR F0
	CPL F0
	CLR F1
	CPL F1
		*JNI addr
		JF0 addr
		JF1 addr
		
		*replaced by JT0, JNT0
			ENTOCLK

TABLE 4—SCN8400 MACROS FOR USE WITH AN 8048 ASSEMBLER

```
LINE                                        SOURCE STATEMENT

 1 $MACROFILE
 2 ;MACROS FOR 8048 ASSEMBLER RECOGNITION
 3 ;OF 8400 COMMANDS
 4                                          MOVS0A     MACRO            ;MOV S0,A
 5                                          DB 3CH
 6                                          ENDM
 7                                          MOVAS0     MACRO            ;MOV A,S0
 8                                          DB 0CH
 9                                          ENDM
10                                          MOVS1A     MACRO            ;MOV S1,A
11                                          DB 3DH
12                                          ENDM
13                                          MOVAS1     MACRO            ;MOV A,S1
14                                          DB 0DH
15                                          ENDM
16                                          MOVS2A     MACRO            ;MOV S2,A
17                                          DB 3EH
18                                          ENDM
19                                          MOVS0      MACRO L          ;MOV S0,#DATA
20                                          DB 9CH,L
21                                          ENDM
22                                          MOVS1      MACRO L          ;MOV S1,#DATA
23                                          DB 9DH,L
24                                          ENDM
25                                          MOVS2      MACRO L          ;MOV S2,#DATA
26                                          DB 9EH,L
27                                          ENDM
28                                          ENSI       MACRO            ;EN SI
29                                          DB 85H
30                                          ENDM
31                                          DISSI      MACRO            ;DIS SI (Disable serial interrupt)
32                                          DB         95H
33                                          ENDM
34;
35; PORT 0 INSTRUCTIONS
36;                                         INAP0      MACRO            ;IN A,P0
37                                          DB         08H
38                                          ENDM
39;
40                                          OUTP0A     MACRO            ;OUTL P0,A
41                                          DB         38H
42                                          ENDM
43;
44                                          ORLP0      MACRO L          ;ORL P0,#DATA
45                                          DB         88H,L
46                                          ENDM
47;
48                                          ANLP0      MACRO L          ;ANL P0,#DATA
49                                          DB         98H,L
50                                          ENDM
51;
52; DATA MEMORY INSTRUCTIONS:
53                                          DECAR0     MACRO            ;DEC @R0
54                                          DB         0C0H
55                                          ENDM
56;
57                                          DECAR1     MACRO            ;DEC @R1
58                                          DB         0C1H
59                                          ENDM
60;
61;SELECT MEMORY BANK INSTRUCTIONS
62                                          SELMB2     MACRO            ;SEL MB2
63                                          DB         0A5H
64                                          ENDM
65;
66                                          SELMB3     MACRO            ;SEL MB3
67                                          DB         0B5H
68                                          ENDM
69;
70; CONDITIONAL JUMP INSTRUCTIONS
71                                          DJNZA0     MACRO L          ;DJNZ @R0,ADDR
72                                          DB         0E0H,L AND 0FFH
73                                          ENDM
74;
75                                          DJNZA1     MACRO L          ;DJNZ @R1,ADDR
76                                          DB         0E1H,L AND 0FFH
77                                          ENDM
78;
79                                          JNTF       MACRO L          ;JUMP IF TIMERFLAG IS NON ZERO
80                                          DB         06H,L AND 0FFH
81                                          ENDM
82
83; END OF MACRO DEFINITIONS
```

Slaves having a device address and a subaddress interpret the first byte as the device address, the second as the subaddress, and all following bytes as data.

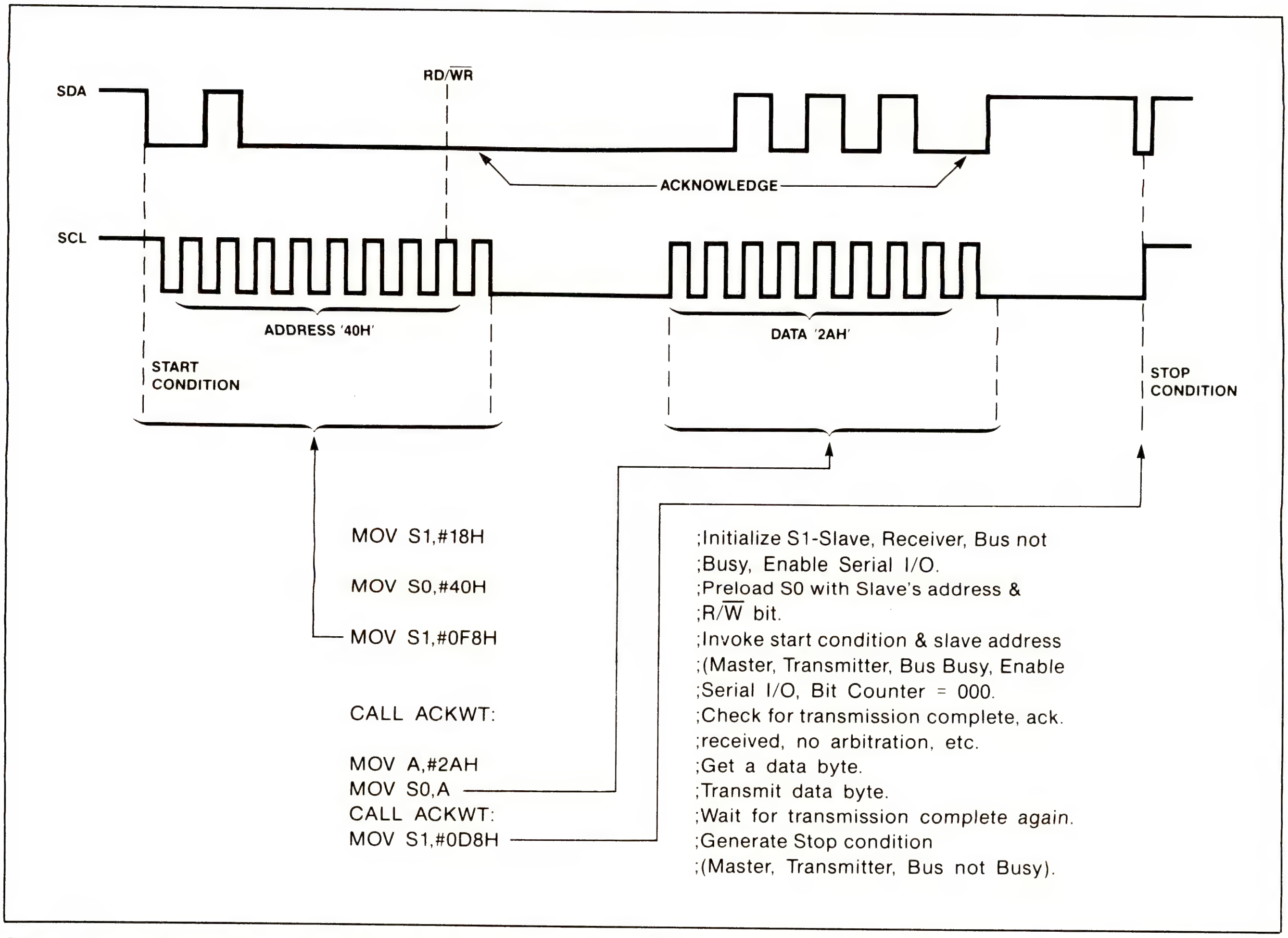
The serial I/O instructions of the SCN 8400 move data to and from the S_0 (data shift register and address register), S_1 (bus control), and S_2 (clock control) registers. The clock line (SCL) of the serial bus has exclusive use of pin 3. Pin 2, however, is shared between the serial data line (SDA) and the parallel I/O signal P_{23} of port 2. Consequently, when the I²C interface is enabled, only three I/O lines are available to port 2.

I²C bus arbitration

Because the I²C devices' serial-clock frequency is under program control, and because the clock circuitry is self-synchronizing, controllers having different clock speeds can access the bus without contention. During arbitration, the resultant clock on the bus has a low period equal to the longest of the low periods and a high period equal to the shortest of the high periods. If two masters attempt to drive the bus simultaneously, their data is ANDed; whichever master generates a low while the other is generating a high will win arbitration. The resultant bus level will be low.

The losing master withdraws from the bus and sets its arbitration-lost flag (the AL bit in register S_1); it is then configured as a slave that can be addressed by the winning master during that master's current operation. You can write subroutines in such a way that the software for any one of the controllers can regard other masters as transparent, so you can put several masters on the bus.

To use the I²C bus effectively in your system, you'll need to understand how to write software routines for driving the bus. Consider the transactions involved when a master addresses, and writes one byte to, a slave that has only a device address **(Fig 4)**. At first,



```
MOV  S1,#18H       ;Initialize S1-Slave, Receiver, Bus not
                   ;Busy, Enable Serial I/O.
MOV  S0,#40H       ;Preload S0 with Slave's address &
                   ;R/W bit.
MOV  S1,#0F8H      ;Invoke start condition & slave address
                   ;(Master, Transmitter, Bus Busy, Enable
                   ;Serial I/O, Bit Counter = 000.
CALL ACKWT:        ;Check for transmission complete, ack.
                   ;received, no arbitration, etc.
MOV  A,#2AH        ;Get a data byte.
MOV  S0,A          ;Transmit data byte.
CALL ACKWT:        ;Wait for transmission complete again.
MOV  S1,#0D8H      ;Generate Stop condition
                   ;(Master, Transmitter, Bus not Busy).
```

Fig 4—A simple instruction sequence performs a 1-byte data transfer *from the master to a slave. The diagram shows the conditions of the data and clock lines for start, stop, read/write control, and acknowledgments.*

you load data 18H into the master's S_0 register, initializing the master to a known state (slave, receiver, bus not busy).

To initiate the transfer, you'll first have to load the master's S_0 register with the slave's device address (in this example, 40H). The fact that the least significant bit of the address is 0 indicates that the transfer will take place from master to slave (ie, a write operation). To transmit this byte, preceded by a start condition, you'll have to set the MST, TRX, BB, PIN, and ESO bits of register S_1. Because you want to generate eight clocks plus an acknowledge clock, set the bit counter (bits BC_{2-0}) to 000. Loading 0F8H into register S_1 sets all these bits correctly. The hardware now begins shifting the address byte out to the bus.

The slave at bus address 40H recognizes that it's being addressed and pulls the data line low during the ninth clock pulse. The ACKWT subroutine (**Listing 1**) continuously checks the status of the PIN bit in register S_1. When this bit goes low, transmission is complete, and the subroutine then checks bit 0 (LRB), which is reset by the slave's acknowledgment.

If the LRB is still high, the slave has not acknowledged the address byte, and the JB0 instruction transfers control to an error routine. If the LRB is low, indicating correct acknowledgment, the RET instruction returns control to the calling routine. As an alternative to polling the PIN bit, the software can enable the serial interrupt (using the EN SI instruction); the occurrence of the interrupt indicates that sending is complete and the software can then check the LRB for a proper acknowledgment.

In a multiple-master system, the ACKWT subroutine must check other conditions. For example, you'll have to look for a possible arbitration-lost situation by checking the AL bit. If arbitration has indeed been lost, it's possible that some other controller is addressing the master as a slave; you can see whether this situation is true by checking the AAS bit. If no other controller is addressing the master as a slave, ACKWT should directly transfer control to a routine that will attempt retransmission.

After a successful address transfer, a data byte is loaded into the accumulator (in this example, the constant 2AH is loaded by a Move Immediate instruction) and is then transferred to the S_0 register. Because the control bit associated with the address called for a write operation, the hardware will automatically start sending this data byte.

LISTING 1

```
ACKWT:   MOV A,S1        ;Get bus status word
                         ;from S1.
         JB4 ACKWT       ;Poll the PIN bit
                         ;until it goes low
                         ;indicating transfer
                         ;completed.
         JBO BUSERR      ;Jump to BUSERR
                         ;routine if acknowledge
                         ;not received.
         RET             ;transfer complete,
                         ;acknowledge received—return.
```

The software then calls the ACKWT subroutine once more to check that the byte has been completely sent and acknowledged. The program terminates the transfer by loading 0D8H into the S_1 register, resetting the BB bit, and thereby causing the hardware to generate a stop condition (ie, the data line makes a low-to-high transition while the clock line is high). This stop condition resets the BB flag on all other controllers on the bus. At the addressed slave, the hardware transfers the received byte from the shift register to an output latch and holds it there until the slave software reads it via the local μP bus.

Reading one byte from a slave

To read one byte from a slave that has only a device address, you can use a very similar instruction sequence (**Fig 5**). The slave address is 41H instead of 40H, the 1 in the LSB indicating a read operation instead of a write. The slave software calls the ACKWT subroutine, as in the write operation, to check for the slave's acknowledgment of the address byte. However, the acknowledgment procedure for this operation is different from that for the write operation. In the read operation, the master can read any number of bytes from the slave and will generate a normal acknowledgment after each one except the last.

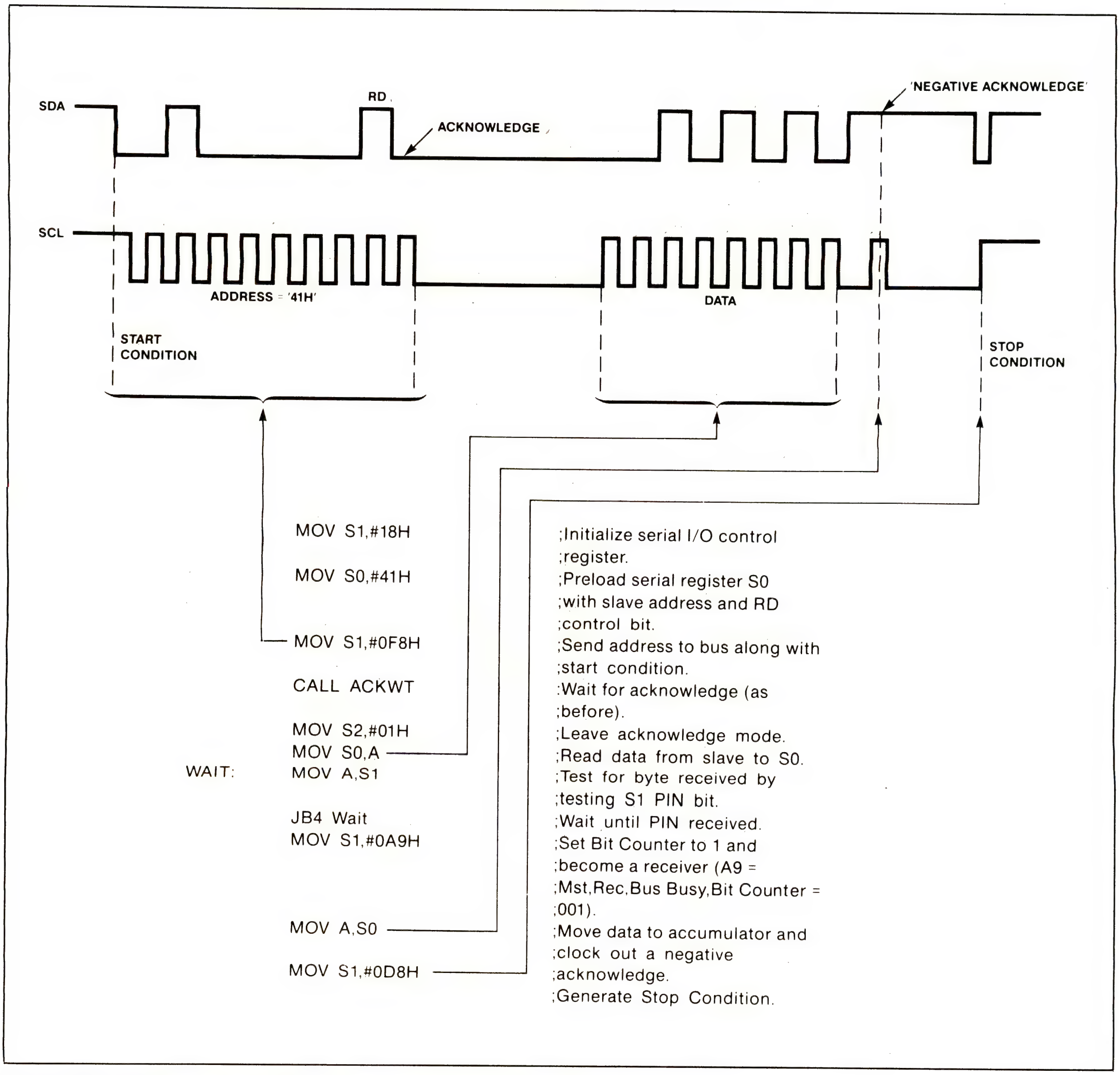
The master must tell the slave when the read operation is complete; it does so by generating a negative acknowledgment after the last byte, that is, by putting a high level on the data line during the ninth clock pulse of the last byte. To put a high level on the data line, the master leaves the acknowledgment mode just before the last byte; reads the last byte, generating only eight bit-clock pulses; prepares to send a 1-bit negative-acknowledgment pulse by loading the binary number 001 into the bit counter of register S_1; and finally moves the contents of register S_0 into the accumulator.

You can use any standard 8048 assembler program, with some additional macros, to assemble programs for the SCN 8400 and PCD 3343 8-bit microcontrollers.

This move instruction (MOV A,S0) performs two functions simultaneously: it transfers the last byte into the accumulator for processing, and it produces one clock pulse on the SCL line. At this point, the data line is held high by the pullup resistor, so the slave interprets the final clock pulse as a command to terminate the operation. The final instruction executed by the master software (MOV S1,#0D8H) generates a stop condition and frees the bus.

Transferring multiple bytes

Devices such as static RAMs or clock/calendar chips generally need to transfer multiple bytes in each operation; furthermore, such devices generally require sub-



```
        MOV S1,#18H     ;Initialize serial I/O control
                        ;register.
        MOV S0,#41H     ;Preload serial register S0
                        ;with slave address and RD
                        ;control bit.
        MOV S1,#0F8H    ;Send address to bus along with
                        ;start condition.
        CALL ACKWT      :Wait for acknowledge (as
                        ;before).
        MOV S2,#01H     ;Leave acknowledge mode.
        MOV S0,A        ;Read data from slave to S0.
WAIT:   MOV A,S1        ;Test for byte received by
                        ;testing S1 PIN bit.
        JB4 Wait        ;Wait until PIN received.
        MOV S1,#0A9H    ;Set Bit Counter to 1 and
                        ;become a receiver (A9 =
                        ;Mst,Rec,Bus Busy,Bit Counter =
                        ;001).
        MOV A,S0        ;Move data to accumulator and
                        ;clock out a negative
                        ;acknowledge.
        MOV S1,#0D8H    ;Generate Stop Condition.
```

Fig 5—The instruction sequence for a master to read one byte from a slave *is more complex than the sequence for writing one byte to a slave, because the direction of transfer changes after the transmission of the slave's device address.*

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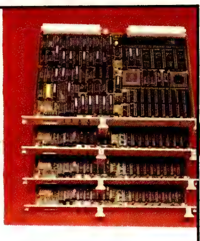

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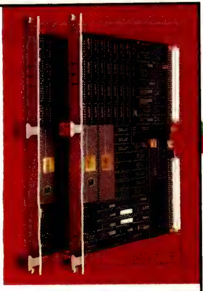

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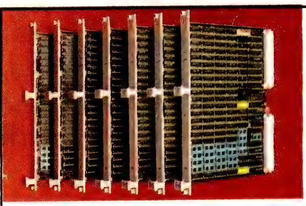

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2 Mbytes RAM
Parity
32 bit data, and address

MEM-3 4MB
4 Mbytes RAM

MEM-3 6MB
6 Mbytes RAM

MEM-1
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16 bit Data, 24 bit Address

MEM-2
2 Mbytes RAM
Parity or Error Correction
16 bit Data, 24 bit Address

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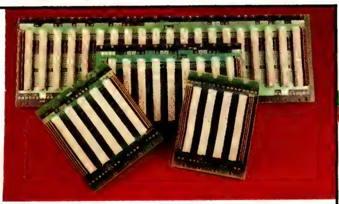

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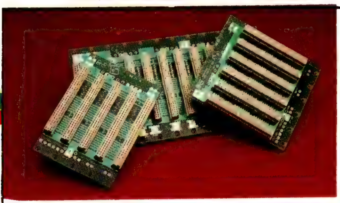

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CIRCLE NO 81

Because the software for any one of the controllers can regard other masters as transparent, you can put several masters on the bus.

addresses to define a starting address for the transfer (RAM) or to allow access to a specific time or date register (clock/calendar). During a write operation on the I²C bus, the subaddress byte immediately follows the device-address byte and is automatically interpreted by the peripherals as an internal address.

To read three consecutive bytes from a PCB8571 CMOS 128-byte static RAM, starting at RAM location 00H, you can use the instruction sequence in **Listing 2.** The master sends a start condition, followed by the device address and subaddress. A repeated start condition, followed by the device address with the read bit set, reverses the direction of the transfer. The master now reads locations 00H through 02H of the RAM and puts the data in registers R_0 through R_2. As in the operation shown in **Fig 5,** the master uses the ACKWT subroutine to send a normal acknowledgment after each byte except the last. To check reception of the last byte and to generate the negative acknowledgment that signals completion of the transfer, the master uses the WAIT1 sequence.

LISTING 2

```
        MOV S1, #18H      ;Initialize bus-status register
                          ;Master, Transmitter,
                          ;Bus-not-Busy, Enable SIO.
        MOV S0, #0A0H     ;Load S0 with RAM's chip
                          ;address.
        MOV S1, #0F8H     ;Start cond. and transmit
                          ;address.
        CALL ACKWT        ;Wait until address received.
        MOV A,#00H        ;Set up for transmitting RAM
                          ;location address.
        MOV S0,A          ;Transmit first RAM address.
        CALL ACKWT        ;Wait.
        MOV S1, #18H      ;Set up for a repeated Start
                          ;condition.
        MOV A,#0A1H       ;Get RAM chip address & RD bit.
        MOV S0,A          ;Send out to bus
        MOV S1,#0F8H      ;preceded by repeated Start.

        CALL ACKWT        ;Wait.
        MOV A,S0          ;First data byte to S0.
        CALL ACKWT        ;Wait.
        MOV A,S0          ;Second data byte to S0.
                          ;And First data byte to Acc.
        CALL ACKWT        ;Wait.
        MOV R0,A          ;Save first byte in R0.
        MOV A,S0          ;Third data byte to S0
                          ;and second data byte to Acc.
        CALL ACKWT        ;Wait.
        MOV R1,A          ;Save second data byte
                          ;in R1.
        MOV S2,#01H       Leave ack. mode.
                          ;Bit Counter = 001 for neg ack.
        MOV A,S0          ;Third data byte to acc
                          ;negative ack. generated.
        MOV R2,A          ;Save third data byte in R2.
WAIT1:  MOV A,S1          ;Get bus status.
        JB4 WAIT1         ;Wait until transfer complete.
        MOV S1,#0D8H      ;Stop condition.
        MOV S2,#41H       ;Restore acknowledge mode.
```

Programs must provide for error handling

In the routines described, the ACKWT subroutine checks to see that the slave acknowledges receipt of a byte sent to it. Failure of the slave to acknowledge may mean either that the slave malfunctioned or that noise on the bus prevented reception. In either case, your BUSERR error-handling routine, to which ACKWT will transfer control, must reinitialize the bus by issuing a stop condition.

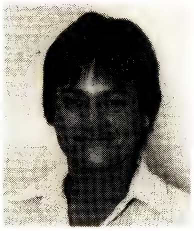
Other functions performed by the error handler will depend upon the requirements of your particular application; however, the error handler should, at the very least, repeat the transfer a certain number of times and, if the error persists, activate a backup device or signal a human operator. In either case, the error handler should identify the malfunctioning slave and the point in the program at which the failure occurred.

If you're setting up a multiple-master system, you'll have to modify your software to detect and handle bus collision and arbitration. These modifications will depend largely on your application and the configuration of your system. **EDN**

Acknowledgments

The author would like to acknowledge the I²C software development performed by Hans Wijnen of NV Philips Elcoma, Eindhoven, The Netherlands. He would also like to acknowledge the technical guidance extended by Nabil G Damouny, applications manager at Signetics.

Author's biography



Carl K Fenger is an applications engineer in the Linear division of Signetics Corp. He is responsible for applications support of the I²C bus, as well as of the company's speech-synthesis and telephony products. Carl holds a BS in Electrical and Computer Engineering from the University of California at Santa Barbara. Carl is a classical pianist, and he enjoys electronic music, scuba diving, skiing, and traveling.

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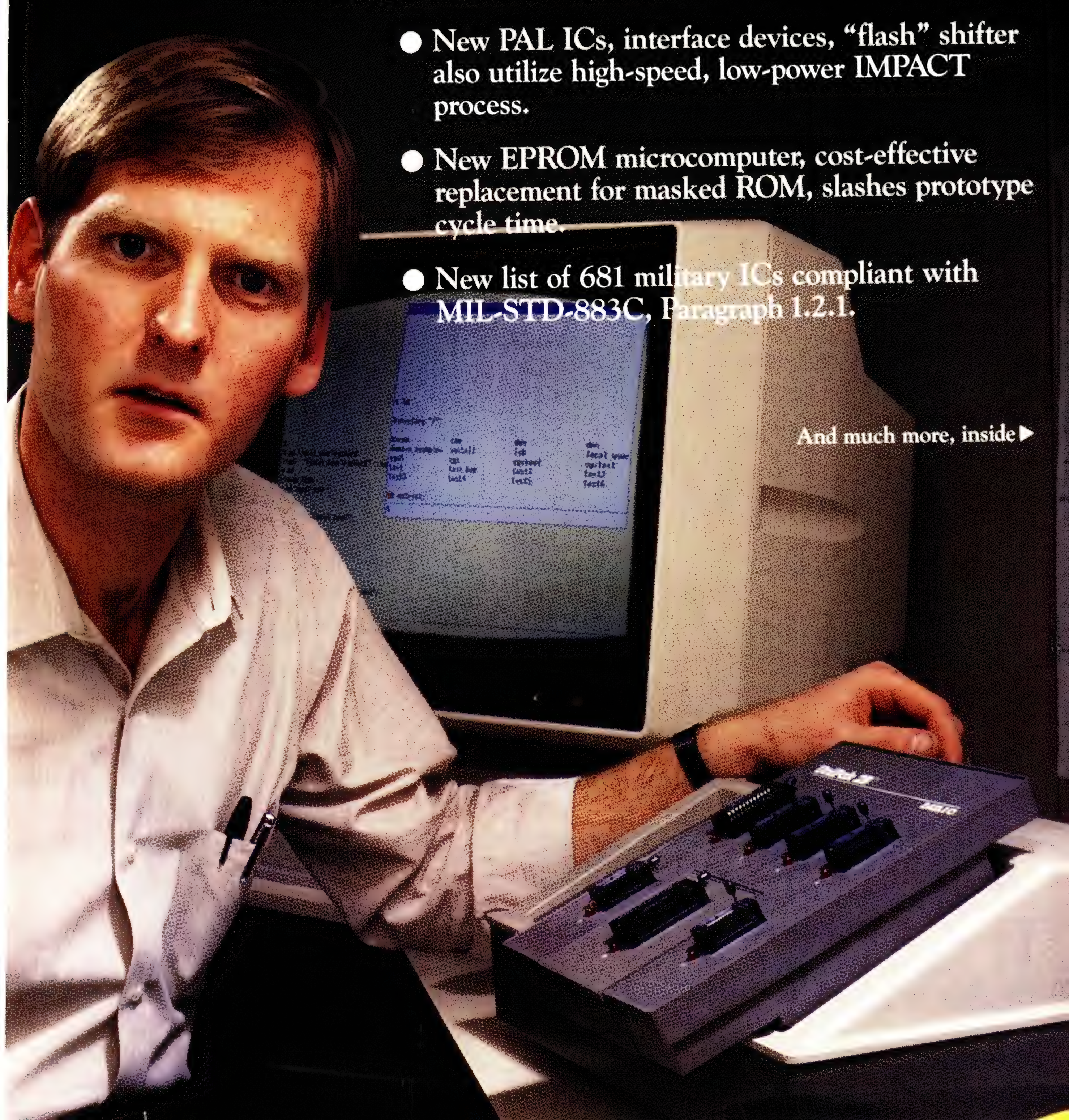
- New list of 681 military ICs compliant with MIL-STD-883C, Paragraph 1.2.1.



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IMPACT PROMs deliver 25-ns speed at industry-standard power.

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Or use the world's fastest 16K registered PROMs. TI's TBP34R165-18 (2K × 8), with a minimum address-to-clock setup time (t_{su}) of only 18 ns, is nearly *2¼ times* faster than the closest competitor. And the TBP34R162-30 (t_{su} = 30 ns) is the only 4K × 4 registered PROM on the market.

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Reliability built in

IMPACT PROMs are designed by TI for exceptional reliability. Current densities, metal spacing, and contact sizes are all conservatively designed. Electrostatic-discharge tolerance up to 4,000 V is designed in. During programming, TI-developed titanium-tungsten fuse links insulate themselves with titanium-oxide caps. Electromigration is eliminated by copper-doped aluminum in the first-level interconnection. And you can program any of TI's new Series 3 PROMs on widely available commercial equipment, using TI's standard Series 3 programming algorithm.

Shift 32 positions in less than 29 nanoseconds.

Now TI's 2-µm IMPACT technology also brings you high-speed "flash-shift" operations — with the new 74AS8838 32-bit barrel shifter. Shifting as many as 32 positions in a single 29-ns instruction cycle, it can dramatically increase throughput in such applications as graphics systems, wide-word CPUs, and array processors. At an energy cost of less than 1.5 W, you get higher speed with lower power, in a single 84-pin ceramic pin-grid-array package.

You can program the 74AS8838 for logical, circular, or arithmetic shifts. Its two 3-state, 16-bit outputs give it the versatility to be configured as a 32-bit-in, 32-bit-out barrel shifter, as a 16-bit funnel shifter, or as a 16-bit shifting transceiver. And it can drive buses directly with 24-mA low-level output — with no additional circuitry.

The 74AS8838 barrel shifter, first device in TI's 74AS88XX 32-bit processor chip set, is available today through your local authorized Texas Instruments distributor.

IMPACT technology doubles speed of new PAL ICs.

Four new exclusive-OR programmable-array logic (PAL®) ICs from TI feature the highest speed available today. Their 20-ns propagation delay at 180 mA makes them twice as fast as any comparable devices.

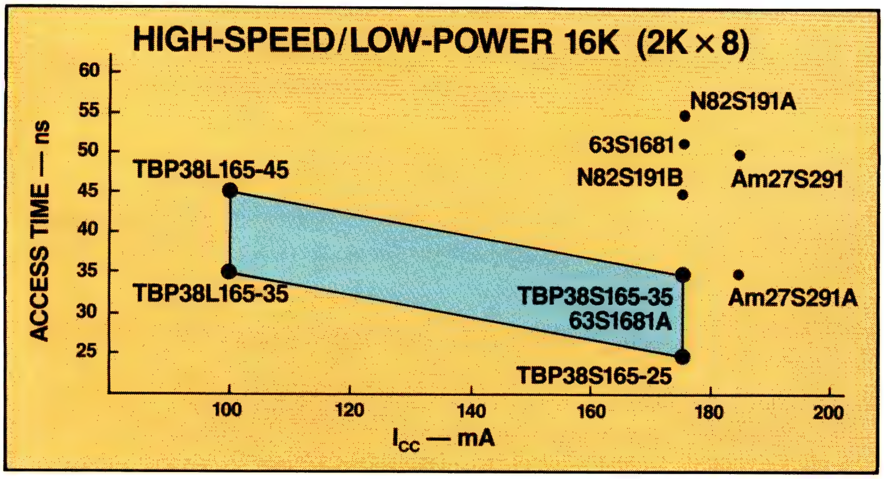
These devices — TIBPAL20L10-20, TIBPAL20X4-20, TIBPAL20X8-20, and TIBPAL20X10-20 — are designed primarily for counter-intensive applications. The exclusive-OR feature suits them ideally to digital voice applications and video-screen information correction. They can also be useful in memory addressing and mapping.

Programmable logic sequencer is 250% faster because of IMPACT processing.

Still another new product in TI's growing line of high-speed programmable logic devices is the TIB82S105B. At 50 MHz, it is 2½ times as fast as functionally equivalent 16 × 48 × 4 field-programmable logic sequencers — at the same 180-mA power. Unlike them, however, it maintains that speed even when using many product terms.

Because of its improved clocking scheme, the IMPACT TIB82S105B is not a direct replacement for the TI or Signetics N82S105A. But it is ideal for those new high-speed state machines designed to control peripheral I/O, dynamic memory systems, and video blanking systems.

For more detailed information about any of TI's growing line of high-speed, low-power IMPACT products, just check the appropriate box on the attached reply card and return it to TI.



Bracketing the speed/power spectrum, TI's IMPACT PROMs cut power requirements from 180 to 100 mA for "standard" 35- to 45-ns access time. Or at 180 mA, they can give you 25-ns speed.

High-density IMPACT circuits speed logic, memory access.

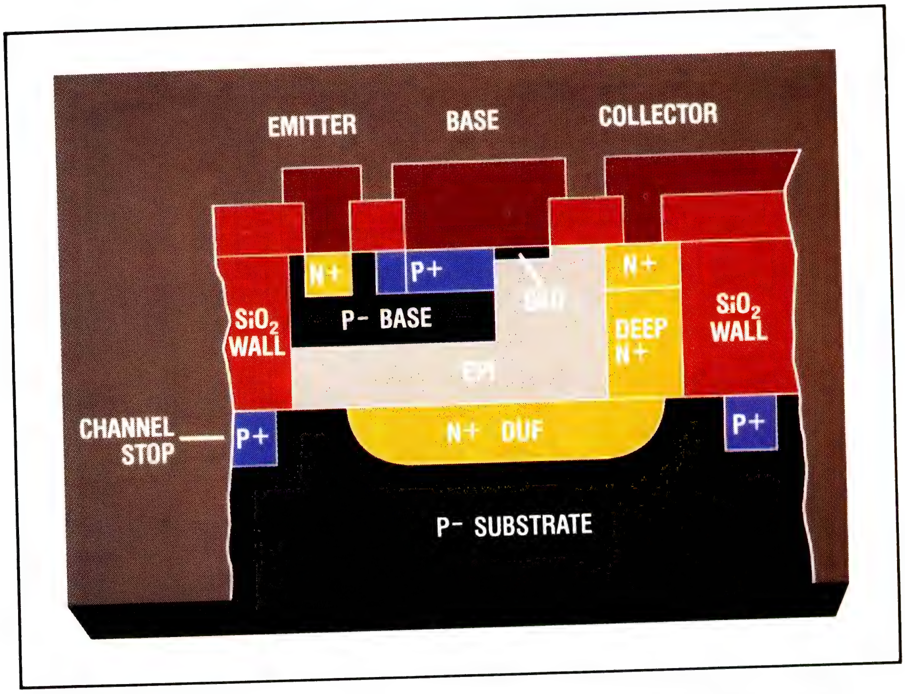
TI's unique Implanted Advanced Composed Technology (IMPACT) capitalizes on the advantages of ion implantation, oxide isolation, and composed-masking techniques to increase the speed and density of bipolar ICs.

This innovative technology dramatically reduces the size and the sidewall capacitance of circuit elements (*see diagram*). As a result, speed/power ratios are significantly improved: In PROMs that cut power consumption by 43%, or more than double the speed (*see story opposite*). In PAL ICs that reduce propagation delay by as much as 40% — to only 15 ns at 180 mA.

With the high speed and low power that TI's IMPACT process makes feasible, its potential for large-scale integration will reduce package counts in many high-complexity circuits.

Composed masking yields high density

In composed masking, critical components are defined on the chip with a minimum number of masks. Thus they can be more tightly defined and more densely spaced than by conventional masking.



A major reduction in capacitance results from the 2-μm feature size which TI's IMPACT processing makes possible. Silicon dioxide is the isolation material. Switching speed is further enhanced by utilizing this silicon dioxide for emitter and base sidewalls.

The IMPACT process also makes it possible to insulate critical base and emitter components with oxide walls. This insulation reduces sidewall capacitance, which, at the 2-μm dimensions of IMPACT features, can represent as much as half the overall capacitance. Small size and oxide walling together contribute significantly to the increase in switching speed.

DRAM technology spurs IMPACT growth

The IMPACT process is not a direct descendant of DRAM technology. Nevertheless, TI's commitment to DRAM production has provided IMPACT technology with vital processes.

It was the DRAM effort, for example, that drove photolithography to its present advanced state and contributed key dry-etching processes. Ion implanters designed to produce CMOS DRAM ICs enhance the quality — and the economy — of TI's bipolar IMPACT ICs. And this vital "cross-fertilization" from VLSI memory is one reason Texas Instruments — almost alone among U.S. semiconductor manufacturers — is committed to the development and manufacture of DRAM devices.

◀ **More chips per slice** help cut costs. The 150-mm wafers now used on TI's advanced MOS 256K DRAM wafer-fabrication line have 125% more area than the 100-mm slices formerly used.

your competitive edge.

6

Keeping you competitive: ASICs and TI.

If you're looking for increased system-level integration and performance, shorter design-cycle time, and reduced VLSI development costs, take a hard look at application-specific integrated circuits (ASICs). And a long look at TI.

Broad choice lets you pick the right implementation

Texas Instruments supports an extensive library of 3-µm CMOS standard cells — more than 200 of the standard SN54/74 TTL functions you have designed with for years — including MSI, analog, and procedural LSI functions like RAM, ROM, PLA, and ALU. In addition, high-drive cells (up to 48 mA) are true TTL replacements.

From TI's new family of advanced standard cells you'll be able to choose among more than 280 functions and achieve increased system integration and performance.

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Whatever level of help you need, you get it from TI. In your design cycle as well as in meeting your prototype and production requirements *on time*. TI's proven expertise and worldwide manufacturing facilities are your assurance of dedicated support and products in the volume you require. And you have a wide range of package options: DIPs, SOs, PLCCs, pin-grid arrays — from 8 to 179 pins.

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You can reduce your costs and speed your ASIC design with TI because you don't need special proprietary software or design tools. And you can do it at a TI regional design center or at your own work station. Because TI's cell libraries are supported by most work stations, including Daisy LOGICIAN®, MEGALOGICIAN®, and GATEMASTER®; Mentor IDEA 1000®; Valid SCALDsystem®; and P-CAD® and FutureNet® in IBM PC® environments.

TI's worldwide network of 13 training and design centers, staffed with experienced ASIC design engineers, can provide access to work stations, as well as mainframe capability. And you can learn ASIC design in one of TI's unique hands-on workshops. Using TI's semicustom libraries with a real-world standard-cell example, you'll learn every phase of design from schematic capture through test-pattern generation and simulation.

Select TI distributors can also give you local access to TI's leading-edge ASIC options, with dedicated facilities, tools, and trained engineers.

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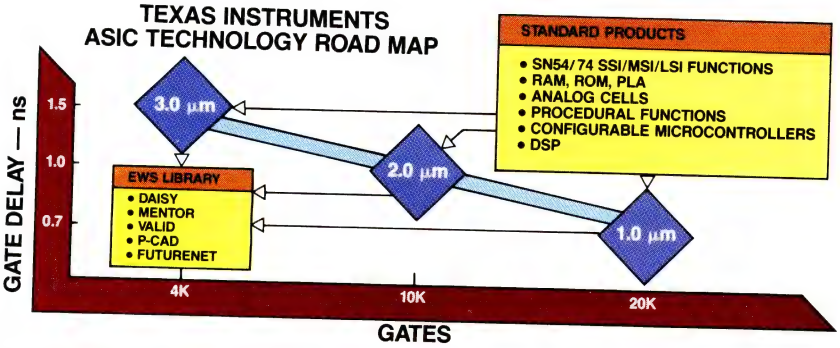


Advancing technology in ASICs need not demand new rules and tools. Your investment in hardware and training is protected when you move up with Texas Instruments to faster, more complex ASIC functions.

7

New series of input-latched and registered PAL ICs lowers parts counts.

Eight new 30 MHz PAL devices from TI are the first input-latched (TIBPALT19XX) and input-registered (TIBPALR19XX) PAL ICs in the marketplace. Functionally similar to TI's TIBPAL20XX series, they include either 11 D-type transparent latches or 11 D-type input registers on chip. This added circuitry allows you to synchronize inputs without external registers or latches. These devices can reduce your parts counts and simplify your design task in a wide range of applications such as random logic, bus-interface logic, and input synchronization to custom controllers.

8

And now, a new, easy-to-use EPROM microcomputer.

TI's new TMS7742 EPROM microcomputer can cut to zero your lead time for development, prototyping, field tests, and product qualification. And it bridges the gap to ROM-based volume production. For low-volume applications, it can be a cost-effective alternative to mask-programmed ROM. Its 4K bytes of on-chip EPROM are identical to TI's TMS2732A — transferred into the chip area vacated by masked ROM. So if you can program the TMS2732A you can program the TMS7742. This new microcomputer provides EPROM capability for the TMS7020, the TMS7040, and the new TMS7042 ROM microcomputer.

Also new to TI's TMS7000 family is the ROM-less TMS7002 microprocessor. Both the TMS7002 and the TMS7042 feature 256 bytes of RAM, a serial port for USART and serial I/O functions, 32 I/O lines, and three timers. And with their 60% performance increase over earlier TMS7000 ICs, they can improve system performance in such applications as disk and tape drives, printers, and industrial and motor controls.

8 new ways TI can help sharpen

1

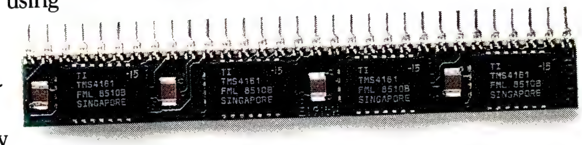
A new alternative for memory-systems lesign: TI SIP DRAM nodules.

Memory-intensive packaging for the fuure is available today — in TI's highly eliable modules in single-in-line packiges (SIPs). With them you can have he many advantages of surface-mount echnology (SMT) — while using hrough-hole-mounted or ocketable packages. Thus vithout changing your manifacturing technology, you an increase memory density y a factor of up to 3.5 over lual-in-line packages (DIPs). And you an simplify board layout while facilitating replacement and future upgrades.

Each SIP module uses DRAM chips n plastic leaded chip carriers (PLCCs), surface-mounted along with decoupling capacitors on an epoxy substrate. Since all connection points are on one edge of the substrate, the module "stands on end" to make the most of your board area.

TI's full line of SIP memory modules — from 64K × 4 to 256K × 9 and 1M × 1 — includes standard DRAMs and Multiport Video RAMs in various organizations. And all are available through your authorized TI distributor.

For more information, just check the appropriate box on the reply card.



Memory can be 3.5 times denser using fully-qualified, production-proven RAMs configured in SIP modules. TI SIPs combine the density of surface-mount technology with economies of through-hole insertion.

2

Interface performance enhanced by TI.

Also new from Texas Instruments is an mproved direct replacement for the JCN5812 vacuum fluorescent display driver. TI's TL5812 is 11% faster and draws 60% less current. With an output voltage swing of 70 V and an output source-current capability of 40 mA.

Only TI's patented BIDFET technology — combining bipolar, double-diffused MOS (DMOS) and N-channel and P-channel CMOS transistors on the same chip — makes these improvements possible. And at a competitive price.

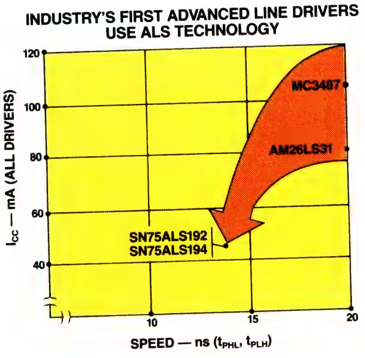
3

Fast line drivers and bus transceivers from TI.

In the new SN75ALS192/194 quadruple EIA Standard RS-422-A differential line drivers, TI's exclusive ALS 1.5 process technology (oxide-isolated Advanced Low-power Schottky) yields the best speed/power ratio in the industry: At approximately half the power consumption, these devices are 30% faster than the competition.

A new family of differential bus transceivers, SN75176B, 177B, 178B, and 179B, are faster than earlier versions. Designed for bidirectional communication on multipoint transmission lines in noisy environments, they meet EIA Standards RS-422-A and RS-485. Typical propagation time is only 22 ns.

Want to know more about these new interface products from TI? Just check the appropriate box on the reply card.



Advanced TI line drivers are 30% faster, typically draw only half the power of the devices they are designed to replace.

4

Fast, economical new 8-bit SAR A/D converters.

Now Texas Instruments offers 8-bit SAR (serial-approximation resolution) A/D converters that are as economical as any you can use. And because they use LinCMOS™ polysilicon-gate-process technology, they are unsurpassed in speed. TI's TLC549 analog-to-digital converter performs 40,000 conversion cycles per second (cps), while the new TLC548 pushes speed to an unprecedented 45,500 cps. At any supply voltage between 3 and 6 V. And typical power consumption is only 6 mW.

Performance of the serial-approximation algorithm is not only fast. It's accurate: Conversions are performed with the guaranteed low error rate of ±0.5 LSB (least significant bit) across the temperature range from −55° to 125°C.

5

681 military TI devices comply with 1.2.1.

Now designers of military electronics have the broadest choice ever of devices that comply with the requirements of MIL-STD-883C, Paragraph 1.2.1. The vast majority of TI's military ICs — 681 different devices — now qualify:

Product Type	Number
ALS/AS	83
TTL	131
LS/S	238
HCMOS	80
PAL ICs	16
Linear	113
Memory/LSI	19
MOS DSP	1
TOTAL:	681

For more detailed information on specific TI military devices, just check the appropriate box on the reply card.

Texas Instruments quality recognized in Tokyo and Detroit

Outstanding Texas Instruments quality-assurance programs were lauded during 1985 both at home and abroad. In June, Ford Motor Company granted TI linear products the coveted Q1 Award. And in November, TI's wholly owned Japanese semiconductor operation received the prestigious Deming Prize. Both awards recognize exceptional levels of quality and reliability, achieved through aggressive defect-prevention programs.

First Ford Q1 Award to a semiconductor supplier

Ford Motor Company's Q1 Award to Texas Instruments Linear is the first ever to a major U.S. semiconductor manufacturer.

Qualification is based on a demonstrated defect-prevention program, along with Ford's review of warranty returns, specifically keying part numbers to failures. Thus it recognizes both initial product quality and continuing reliability.

Both quality and reliability are attributes that TI Linear has pursued aggressively through its "monitor program," begun in 1979. The goal of the program has been to achieve levels of quality and reliability equal to or better than the best worldwide competition. And the Ford Q1 Award is one visible token of its success.

First U.S. winner of Japan's Deming Prize

At ceremonies on November 11 in Tokyo, the Japanese Union of Scientists and Engineers awarded the prestigious Deming Prize for total quality control to TI's bipolar semiconductor operation in Japan.

The prize, never before won by a wholly U.S.-owned company, recognizes outstanding quality-control achievement in all aspects of business — including marketing, engineering, manufacturing, and support. It is named for W. Edwards Deming, the American statistician whose work in defining and measuring quality control in Japan after World War II became the basis for the legendary Japanese commitment to quality. In 35 years, the Deming Prize has been awarded to only 48 individuals and 111 institutions. Texas Instruments Japan, Ltd. was one of only eight companies so honored in 1985.

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As is the case with the Ford Q1 Award, sensitivity to customers' requirements is a key factor in selecting winners of the Deming Prize. TI's successfu commitment to quality and reliability in support of all our customers' needs has been demonstrated twice again. And TI is justifiably proud of this achievement.

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More news upcoming from TI in the next issue:

- **A new CMOS version** of TI's trend-setting TMS320 Digital Signal Processor.
- **More new additions** to TI's growing family of IMPACT PAL ICs.
- **New CMOS standard cells** and gate arrays that augment TI's leadership in Application-specific Integrated Circuits (ASICs).
- **And more …**

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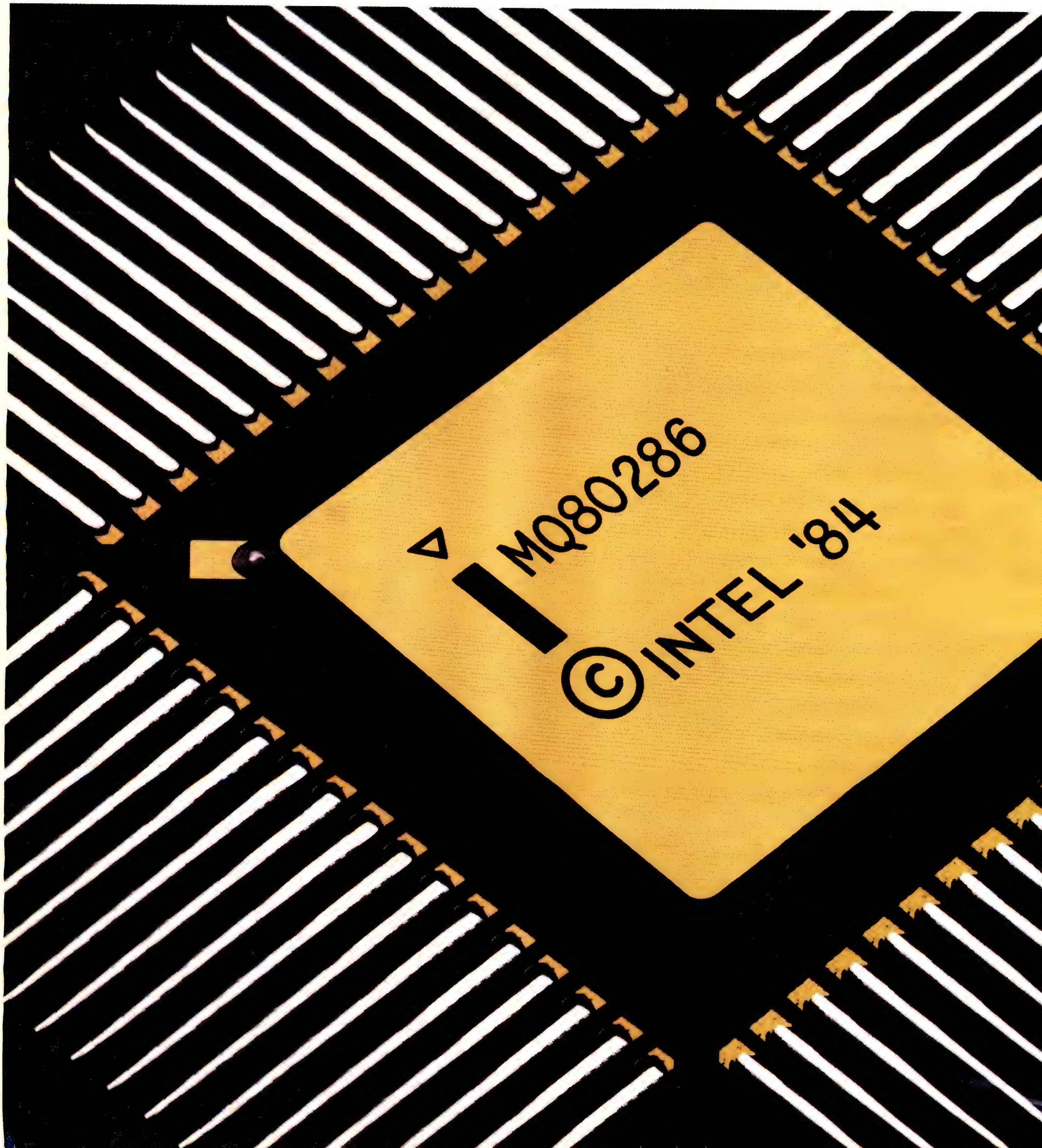
HOW TO RESPOND
978 MICROSECONDS FASTER
THAN THE ENEMY.



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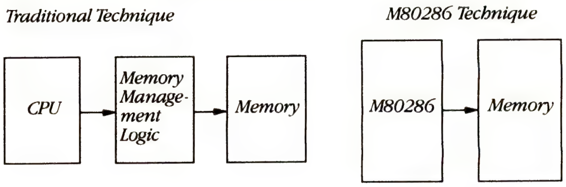

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And because our M80286 chip is based on Intel's high-performance M8086 microprocessor architecture, you are assured of the most powerful and easily upgradable engine available for military designs.

Included in the CPU is a memory management unit that equips the M80286 with hardware support for virtual memory and software protection. Making it ideal for military applications that require processing of massive amounts of information.

Performance is enhanced by exclusive pipelining features that eliminate delays in execution time. So the M80286 can do more instructions per clock than any other CPU.

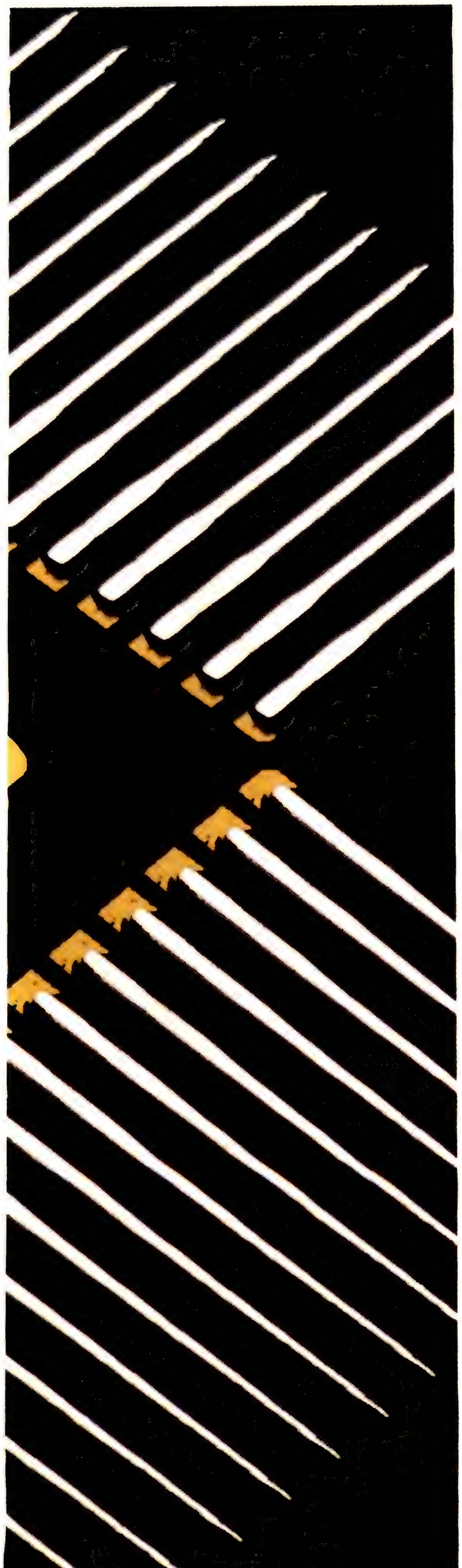
System throughput can be further increased with our broad base of peripheral products. Such as our 80287 coprocessor and 82720 graphics controller. These chips are specifically designed to offload the numerics and graphics functions from the CPU.

In addition, the M80286 is optimized for higher level languages such as ADA. With ADA 286, designers can get greater systems flexibility and maximum performance.

And tomorrow? As your military system requirements grow, an upgrade path based on the same high performance architecture of our M80286 will be available with our 32-bit M80386 microprocessor.

For further information, call toll-free (800) 548-4725. Or write Intel Corporation, Lit. Dept. W281, 3065 Bowers Ave., Santa Clara, CA 95051.

We'll get back to you. Faster than you can blink an eye.



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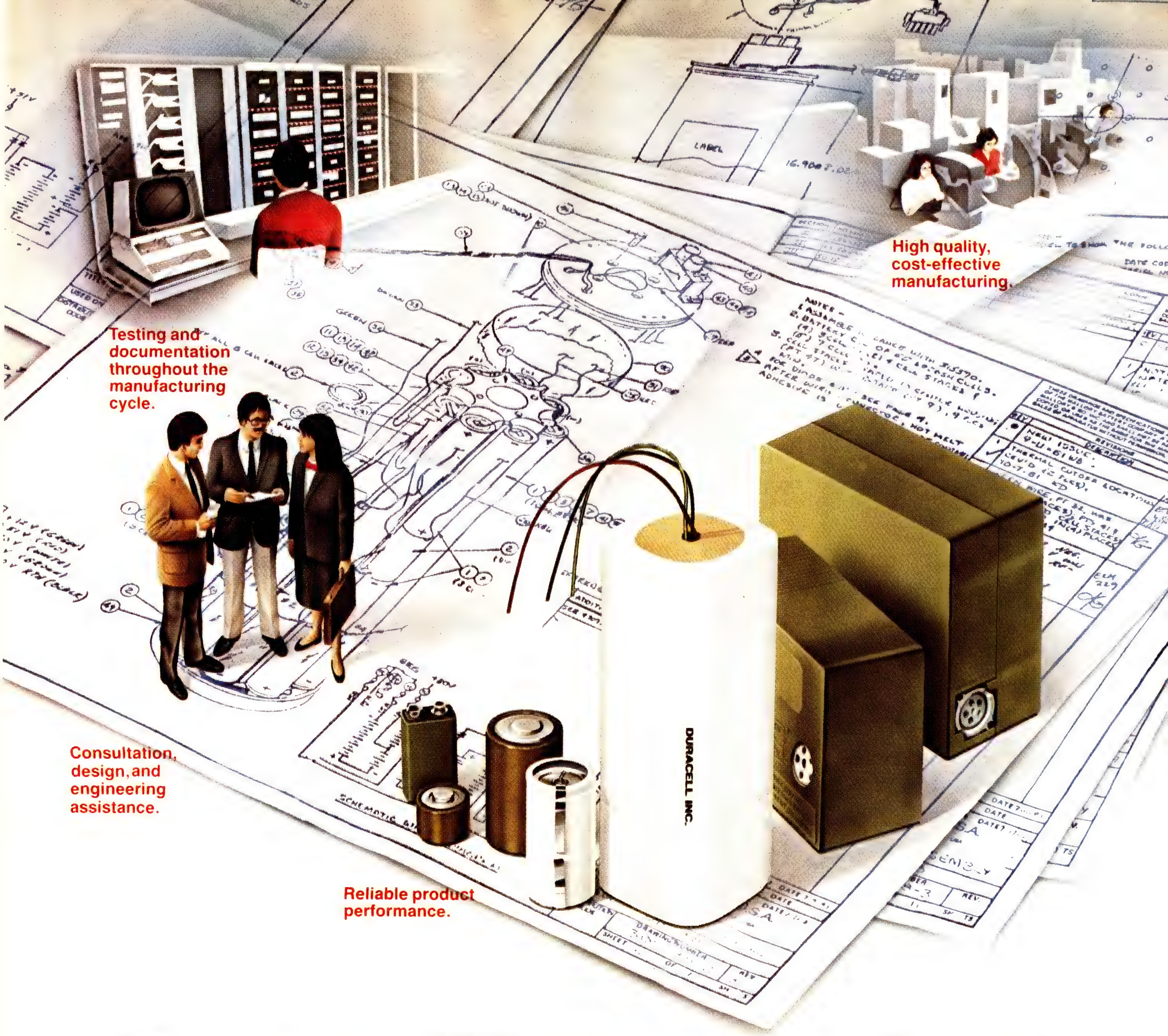
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Designer's Guide to:
Linear control-system theory—Part 1

Apply control-system theory to analyze closed-loop systems

Dynamic signal analyzers (DSAs), which analyze signals in both the time and frequency domains, aid you in taking control-system measurements and in performing other steps in system development, such as analysis, modeling, and design. Part 1 of this 3-part article presents an overview of classical linear control theory. Part 2 will examine both old and new methods of taking the actual measurements, and part 3 will explore the expanded role of DSAs in the control-system design process.

Steve Asbjornsen and Owen Brown,
Hewlett-Packard Co

Control-system development is largely a study of the operating characteristics of devices and the ways in which the devices interact when combined in a system. You can apply linear control-system theory to analyze any system that uses deliberate guidance or manipulation to achieve a specific value for some variable, whether it's electrical, mechanical, or biological. These systems can range from configurations as simple as Watt's flyball governor to networks whose analysis requires calculations that only a computer can handle adequately. Examples of familiar control systems include motor-speed controls, pacemakers, voltage regulators, switching power supplies, and phase-locked loops.

The most fundamental distinction in control theory is the classification of systems. Without exception, systems fall into two categories: open-loop and closed-loop systems. Open-loop control systems **(Fig 1a)** are ones that use a controller that has no feedback from the output. These systems can't take corrective action to alleviate undesired changes in the output. Closed-loop systems **(Fig 1b)** are ones whose output is fed back and compared with the input in such a way as to maintain the desired output. This series of articles will consider only closed-loop systems.

You can represent any closed-loop system with the standardized diagram shown in **Fig 1b.** In the diagram, the output C (the directly controlled variable) feeds back through a functional block with transfer function H and is compared with reference signal R at a summing junction. The difference between R and the feedback signal (B) is the error, or actuating signal (E). The reaction of the components represented by G in response to error signal E maintains the output at the desired level.

If controlled variable C is fed back to the summing

An understanding of classical measurement methods for control systems aids you in using dynamic signal analyzers for design, modeling, analysis, and test.

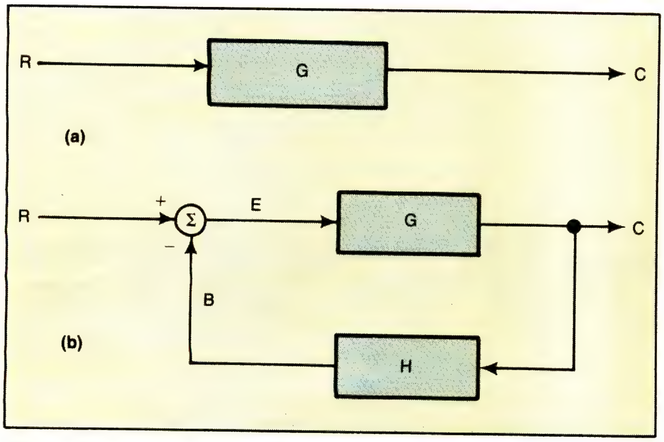


*Fig 1—****The two basic configurations for a system*** *are the open-loop* ***(a)*** *and closed-loop* ***(b)*** *configurations. In an open-loop system, variations in the output go undetected; in a closed-loop configuration, feedback from the output maintains the desired output characteristics.*

junction without any modification, transfer function H will equal one. A system in which H is 1—called a unity-feedback control system—is the easiest type of system for designers to analyze. These block diagrams will help you model a system. To evaluate the system's performance, however, you'll need criteria by which to judge it.

You need to know, for example, how quickly the system achieves the desired output level and whether the system can maintain that level with little or no variation. Control-system designers' need for this basic information led to the first serious study of negative-feedback control systems and ultimately to the development of classical linear control theory.

The first attempts to analyze systems, which were speed regulators on steam engines, took place in the 19th century and involved the use of differential equations. To make the equations as easy as possible to solve, engineers selected a small group of standard inputs that were easy to express mathematically. Chief among these inputs was the step forcing function. Not only was this function simple to express, but it was easy to implement physically, so it permitted the engineer to compare analytical results with measured results.

By using information derived from this step-response technique, you can measure both the speed with which a system reacts to a change in input (rise time) and the degree to which the system temporarily exceeds the desired output level (maximum overshoot). The information also indicates settling time, which is the time it takes for a system to reach a new output level within a given error band **(Fig 2).**

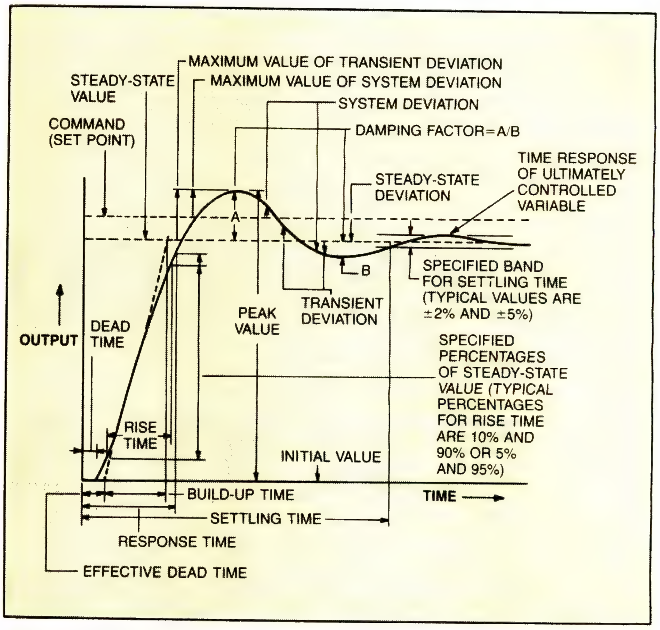

MAXIMUM VALUE OF TRANSIENT DEVIATION
STEADY-STATE VALUE
MAXIMUM VALUE OF SYSTEM DEVIATION
SYSTEM DEVIATION
COMMAND (SET POINT)
DAMPING FACTOR=A/B
TIME RESPONSE OF ULTIMATELY CONTROLLED VARIABLE
STEADY-STATE DEVIATION
A
B
SPECIFIED BAND FOR SETTLING TIME (TYPICAL VALUES ARE ±2% AND ±5%)
TRANSIENT DEVIATION
PEAK VALUE
OUTPUT
DEAD TIME
SPECIFIED PERCENTAGES OF STEADY-STATE VALUE (TYPICAL PERCENTAGES FOR RISE TIME ARE 10% AND 90% OR 5% AND 95%)
RISE TIME
INITIAL VALUE
BUILD-UP TIME
TIME
SETTLING TIME
RESPONSE TIME
EFFECTIVE DEAD TIME

*Fig 2—****This output waveform, a typical response*** *of a system to a step forcing function, can help you evaluate the stability of the system. The overshoot and ringing are good indicators of the system's stability. Settling time to within a given error band is an important parameter for linear amplifiers and D/A converters.*

A system's settling-time spec indicates the relative stability of that system. For example, a system that oscillates around the steady-state value for long periods of time is considered to be less stable than a system whose oscillations die out relatively quickly. A system whose response oscillates indefinitely at either a constant or an increasing amplitude after the system has been excited by a step input is considered to be unstable **(Fig 3).**

Although measuring time-domain responses allowed engineers to verify system models and obtain useful, easily extracted performance information, this method provided few clues to how they could improve a system's performance. Further, as systems became more complex, the solution of the integrodifferential equations used to model them grew correspondingly difficult. Solving these equations became somewhat easier in 1899, however, when Oliver Heaviside introduced partial-fraction expansion techniques. Heaviside's discovery made it possible to use Laplace transforms to simplify the solution of large differential equations.

The Laplace transform

The Laplace transform is the integral of the product of the variables f(t) and e^{-st}. The variable s is complex; it has a real component (σ) and an imaginary component (jω). The transformation of a system's transfer function results in a ratio of polynomial expressions in s. In this format, many of the time domain's complex calculations become simple algebra problems.

Of particular interest to engineers are values of s that would cause either the ratio's numerator or denominator to equal zero. Values that set the numerator to zero force the function represented by the ratio to equal zero in the Laplace domain. These values of s are called zeros. Values of s that cause the denominator to equal zero force the function represented by the ratio to equal infinity in the Laplace domain. These values are called poles. Poles are of special significance: When you transform a function back into the time domain to predict the system's response, the real part of the pole determines the exponents of the response. If an imaginary part of the pole exists, it becomes a frequency component of at least one term of the response.

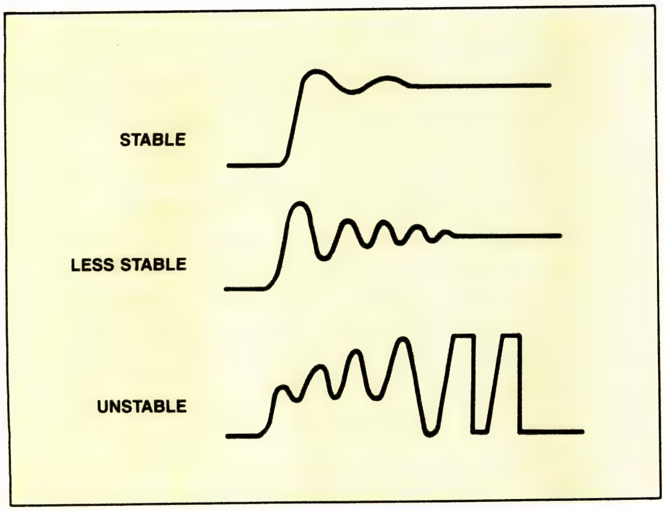
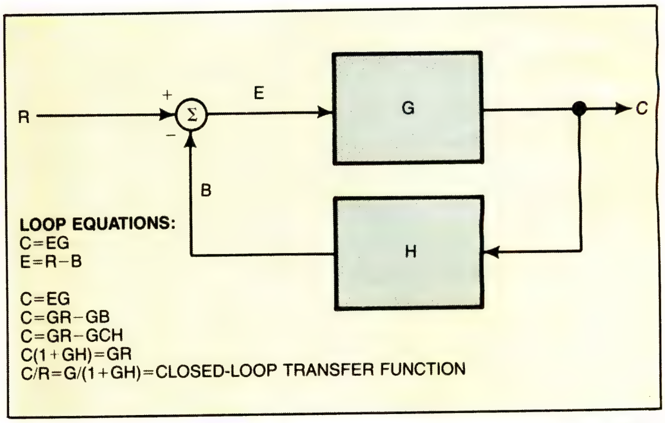


Fig 3—A system's settling characteristic in response to a step-function input *shows how stable the system is. The more ringing there is around the waveform's final value, the less stable the system is. In an unstable system, the ringing never stops, but instead builds up to oscillation.*

In addition, you can use the real part of the poles to determine the system's stability without having to transform the calculations back into the time domain. Poles with positive real values indicate positive exponents in the time domain; therefore, they indicate instability of the control loop.

These Laplace-transform methods were sufficient to solve control-system problems until the early part of the 20th century. With the development of the vacuum tube and large electronic systems, however, the computational aid of the Laplace transform became inadequate for system evaluation. In particular, Harold S Black's use of negative feedback in electronic-amplifier design in the late 1920s spurred engineers to look for more powerful analytical tools.



LOOP EQUATIONS:
C=EG
E=R−B

C=EG
C=GR−GB
C=GR−GCH
C(1+GH)=GR
C/R=G/(1+GH)=CLOSED-LOOP TRANSFER FUNCTION

Fig 4—Simple multiplication, addition, and subtraction *yield the transfer function for a closed-loop control system. The model applies equally well to locomotives and operational amplifiers.*

From Laplace to Nyquist

In the early 1930s, Harry Nyquist discovered that the solution to the problem of analyzing complex systems lay in the frequency domain. His analysis was built upon the extension of several familiar concepts. By expressing the elements of the control loop as transfer functions (ie, the Laplace transform of the output divided by the Laplace transform of the input), simple algebra could provide an expression for the input/output relationship of a system.

By using the block diagram in **Fig 1** and letting C, E, R, and B represent the Laplace transforms of the signals appearing at the lettered points in the system, you can express the input/output relationship of a closed-loop system as C/R=G/(1+GH) **(Fig 4).** This expression is known as the closed-loop transfer function. Reduced to its simplest form, the expression is itself a ratio of polynomials in s.

From previous work in the Laplace domain, engineers already knew that the poles of this closed-loop transfer function would determine the stability of the system. If you look for the closed-loop poles (ie, values of s that force 1+GH to zero), you see that the GH term contains all the information regarding the poles' whereabouts (see **box,** "Polynomials within polynomials"). Therefore, the key to determining the stability of a system is knowing whether any of the values of s that make GH equal −1 (ie, the closed-loop poles) have positive real parts.

Polynomials within polynomials

The terms G(s) and H(s) in the transfer function for a closed-loop system are themselves generally ratios of polynomials in s. You can thus define the terms by using the following expressions:

$$G(s) = \frac{G_n(s)}{G_d(s)}$$

$$H(s) = \frac{H_n(s)}{H_d(s)},$$

where the subscripts n and d indicate the numerator and denominator portions of G(s) and H(s), respectively. If you reformulate the closed-loop transfer function in terms of the numerator and denominator of G(s) and H(s), you obtain the following expression:

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 + GH(s)} = \frac{\dfrac{G_n(s)}{G_d(s)}}{1 + \dfrac{G_n(s)\,H_n(s)}{G_d(s)\,H_d(s)}} = \frac{\dfrac{G_n(s)\,H_d(s)}{G_d(s)\,H_d(s)}}{\dfrac{G_d(s)\,H_d(s) + G_n(s)\,H_n(s)}{G_d(s)\,H_d(s)}}.$$

You express the closed-loop transfer function in this manner to illustrate that the term 1+GH(s) itself has poles and zeros, and that the zeros of this term determine the poles of the closed-loop transfer function. Note also that the zeros of the closed-loop transfer function are the roots of the equation $G_n(s)H_d(s)=0$.

If you could measure GH at each value of s you could simply determine when GH equals −1 and record those values of s. Unfortunately, the only values of GH you can physically measure are those values of s for which the real part equals 0—ie, GH(0+jω), which is commonly expressed as GH(jω). All other values of s simply provide an analytical model for understanding how a system's components will affect its time- and frequency-domain responses. Evaluating GH(jω) provides the input/output relationship of the device, typically in the form of gain and phase shift as a function of frequency. GH(jω), therefore, is called a frequency response, and it represents the frequency-domain characteristics of the system.

Nyquist's stability criterion

Using only the information from evaluating GH(jω), Nyquist had to determine whether there were any values of s (having positive real parts) that satisfied the equation GH(s)=−1. Of course, if GH(jω)=−1 at some frequency ω_1, then it's clear that a closed-loop pole exists at $s=(0+j\omega_1)$. But determining whether there were other closed-loop poles having positive real parts was not easy.

Nyquist's contribution lay in his discovery of a technique in which the closed-loop system's measured open-loop frequency response could be used to determine the existence of any closed-loop poles with positive real parts. The mathematical proof behind Nyquist's stability criterion is not intuitively obvious. However, the graphical representation of this discovery, known as a Nyquist diagram, is simple to use, and it was soon adopted by the engineering community.

In a Nyquist diagram, you plot a system's open-loop frequency response on a graph whose coordinates represent real and imaginary components. To derive this trace, you measure device response at a number of different frequencies. To complete the Nyquist diagram, you also plot the complex conjugate of the response on the same graph, typically using dashed lines **(Fig 5a)**.

Nyquist's criterion states that if you affix the tail of a

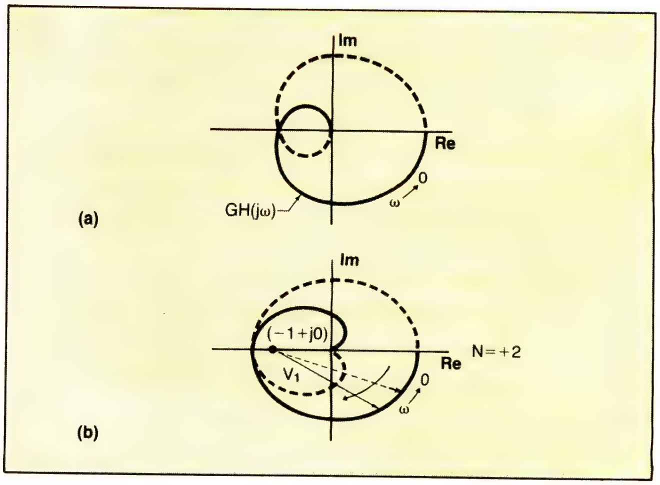


*Fig 5—**The Nyquist diagram (a), a tool for frequency-domain analysis of a system,** is a plot of the system's open-loop frequency response and its complex conjugate. To determine the number of closed-loop poles with positive real parts, count the number of net rotations of vector V_1 in **b**.*

Closed-loop systems compare input signals with feedback signals in such a way as to maintain a precisely controlled output/input relationship.

vector to the point representing −1+j0, allow the head of the vector to trace the entire path created by the open-loop frequency response and its complex conjugate, and then count the net revolutions (N) of that vector, you can determine whether the system has any closed-loop poles with positive real parts **(Fig 5b).**

The stability criterion actually determines the difference (N) between the number of zeros (Z) and the number of poles (P) of the term 1+GH(s), using the equation $N=Z-P$. In systems for which $P=0$ (which is often the case), $N=Z$, which is the number of poles that have positive real parts in the closed-loop transfer function.

The most important aspect of Nyquist's criterion is its usefulness. This tool provides engineers with a way to determine the stability of a control loop by simply measuring the open-loop frequency response. No rigorous mathematical analysis is necessary. Further, Nyquist's criterion allows you to determine the stability of a control loop before closing the loop, thus avoiding possible damage to your system from reactions caused by instability.

The unity-feedback case

For systems with unity feedback (H(s)=1), the Nyquist diagram **(Fig 6)** provides a technique for directly calculating the closed-loop frequency response, G(jω)/[1+G(jω)], from its measured open-loop frequency response G(jω). In this case, two vectors are projected—one from point −1+j0 (V_1) and the other from the origin (V_2)—to extend to the curve G(jω).

V_1 thus represents the term 1+G(jω), and V_2 represents G(jω). The vectors' heads are placed on the open-loop frequency response. You can use simple vector algebra (V_2/V_1) to calculate the input/output relationship of the closed-loop system at the corresponding frequency.

As an alternative to calculating the ratio of the vectors at many frequencies, graphical tools called magnitude contours and phase contours were devel-

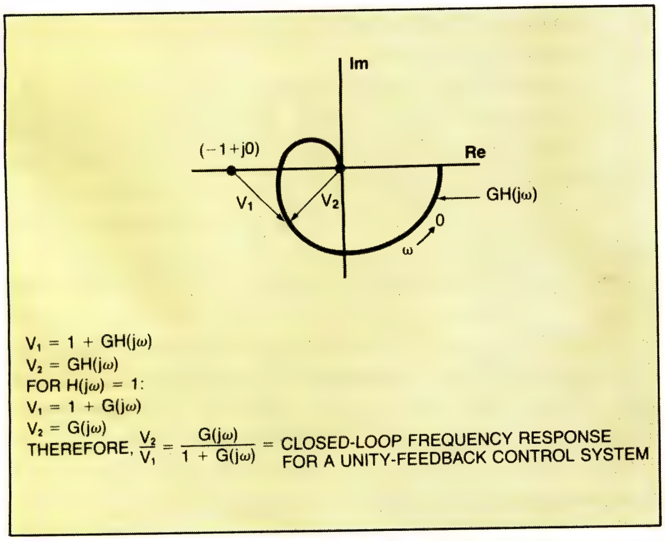

Im
(−1+j0)
Re
V_1
V_2
GH(jω)
0
ω
$V_1 = 1 + GH(j\omega)$
$V_2 = GH(j\omega)$
FOR $H(j\omega) = 1$:
$V_1 = 1 + G(j\omega)$
$V_2 = G(j\omega)$
THEREFORE, $\frac{V_2}{V_1} = \frac{G(j\omega)}{1 + G(j\omega)}$ = CLOSED-LOOP FREQUENCY RESPONSE FOR A UNITY-FEEDBACK CONTROL SYSTEM

Fig 6—To evaluate unity-feedback closed-loop frequency response *from open-loop data, you use vector algebra with a Nyquist diagram. The ratio V_2/V_1 is the output/input response of the closed-loop system at any frequency.*

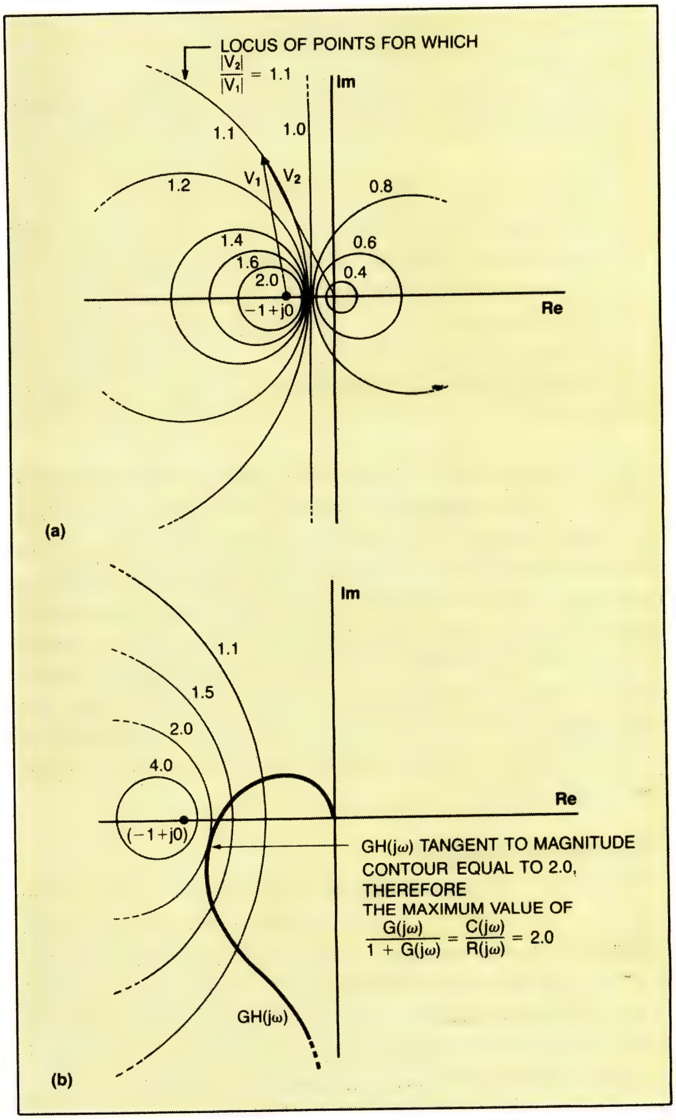

LOCUS OF POINTS FOR WHICH $\frac{|V_2|}{|V_1|} = 1.1$
Im
1.1
1.0
V_1
V_2
1.2
0.8
1.4
0.6
1.6
2.0
0.4
−1+j0
Re
(a)
Im
1.1
1.5
2.0
4.0
Re
(−1+j0)
GH(jω) TANGENT TO MAGNITUDE CONTOUR EQUAL TO 2.0, THEREFORE THE MAXIMUM VALUE OF $\frac{G(j\omega)}{1 + G(j\omega)} = \frac{C(j\omega)}{R(j\omega)} = 2.0$
GH(jω)
(b)

Fig 7—Loci of constant transfer-function magnitude, *or magnitude contours **(a)**, form a family of circles. By plotting an open-loop transfer function against the contours **(b)**, you can identify the gain of the closed-loop function by its intersection with the loci.*

Mathematical techniques by Laplace and Heaviside, and graphical-analysis methods by Nyquist, Bode, and Nichols aid you in predicting closed-loop system response.

Dynamic signal analyzers

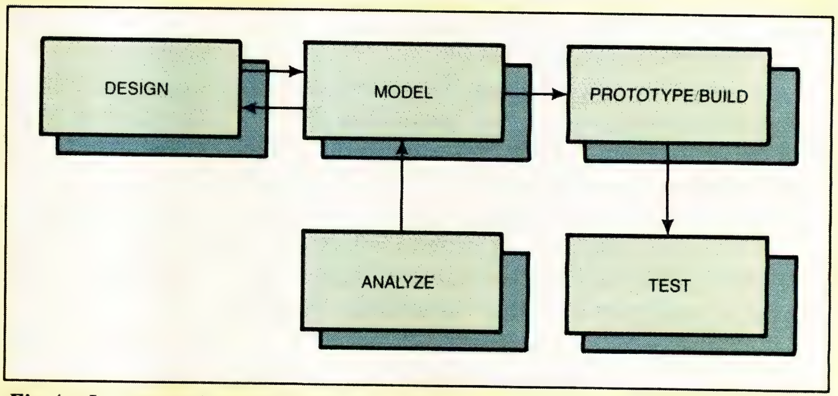


***Fig A—In a typical product- or system-development cycle,** these five processes all play crucial roles. A dynamic signal analyzer (DSA) expands the traditional role of test instruments from the analyzing and testing functions to include significant contributions to the model and design processes.*

Dynamic signal analyzers (DSAs) are low-frequency analyzers that sample signals applied to their inputs and then use Fourier transforms to analyze the signals in both the time and frequency domains. Useful to engineers who take mechanical, acoustic, and audio-electronics measurements, these analyzers record waveforms and take high-speed, single-channel frequency-spectrum and 2-channel frequency-response measurements.

Because they've recently acquired an array of advanced measurement and analysis functions that are directly applicable to control-system measurements, DSAs are replacing frequency-response analyzers in measurement and performance analysis.

However, DSAs are no longer simply measurement instruments; they have new analytical capabilities that, in many respects, equal those of workstations **(Fig A).** These capabilities allow designers who use DSAs to measure a device under test and to model, revise, and perfect the response of the as-yet-unbuilt system.

oped. A magnitude contour **(Fig 7a)** is a locus of points on the Nyquist diagram for which the ratio V_2/V_1 has the same magnitude. When you plot loci for several values of magnitude, the loci form a family of circles. When you plot the open-loop transfer function against these contours, you can identify the gain of the closed-loop transfer function by its intersection with or proximity to a given magnitude contour **(Fig 7b).** You can draw similar loci, called phase contours, for positions of constant phase, and you can use them the same way you use magnitude contours.

Gain, phase margins

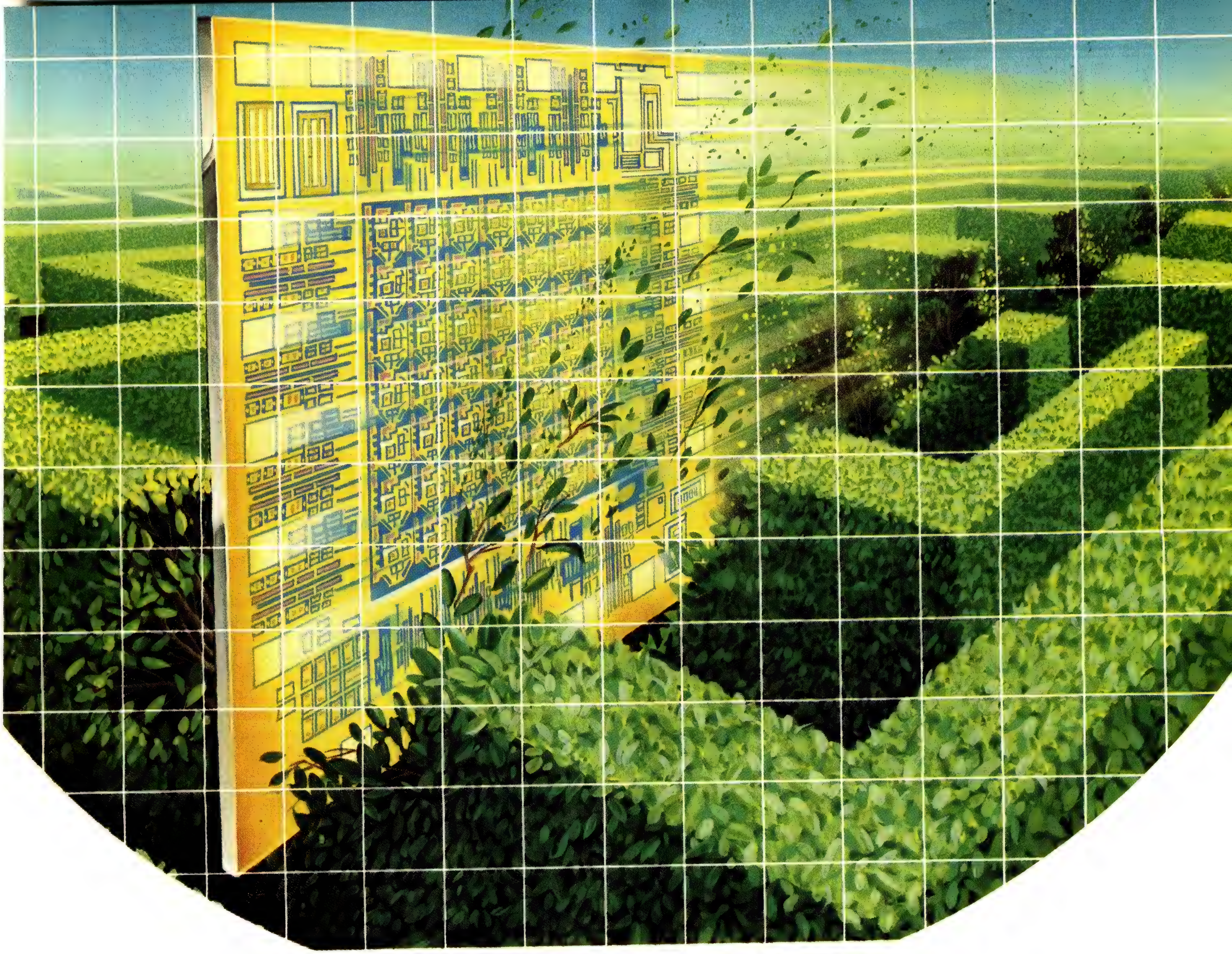
The basic Nyquist diagram generated several other graphical measurement aids. Eight years after Nyquist published his techniques, Hendrik Bode wrote a paper in which he observed that systems should be designed to be absolutely stable, one of two possible states for a stable system. An absolutely stable system is one that has some unique value of frequency-independent gain (K_1), below which the system will always be stable, and above which the system will always be unstable.

Alternatively, a conditionally stable system is one with a gain (K_2) above which the system will generally become unstable. In a conditionally stable system, there is also a band of gains greater than K_2 where the system becomes stable again. However, operating in this higher band requires careful control of gain levels; for this reason, Bode and others considered operating in this band undesirable.

In an absolutely stable system, the open-loop frequency response should cross the negative real axis only between 0 and the −1 point. Bode's observations simplified stability evaluations even further by eliminating the need to plot the frequency response's complex conjugate.

Bode also observed that, as the plot of the open-loop frequency response approaches the value of −1, the real part of a closed-loop pole approaches the value of 0. A system with such a response has longer settling times and, in general, less stability. Therefore, Bode established phase-margin and gain-margin parameters to provide a quantifiable measure of the proximity of the open-loop frequency response to this −1 point.

Bode viewed the Nyquist diagram as a polar plot in which gain is the distance from the origin and phase is measured as an angle with 0° as the positive real axis. The gain margin is the additional gain required to



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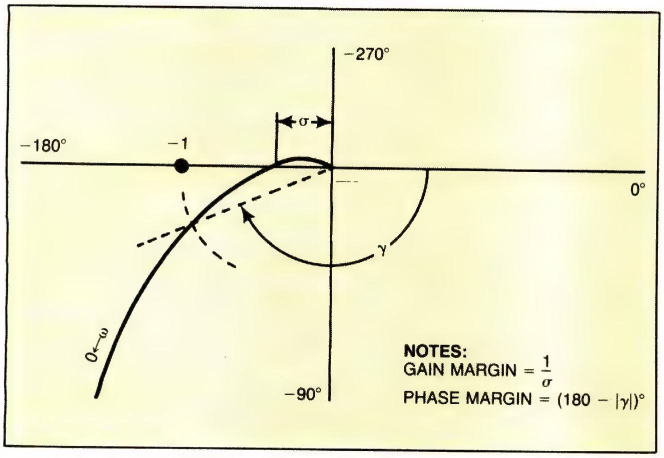
> *Easy to implement in a test system, the step forcing function reveals a wealth of information about a system's speed, stability, and settling time.*



NOTES:
GAIN MARGIN = $\frac{1}{\sigma}$
PHASE MARGIN = (180 − |γ|)°

Fig 8—Measuring gain and phase margin with a Nyquist diagram *is easy. The gain margin is the additional gain needed to achieve unity gain at 180° phase shift, and the phase margin is the additional phase shift needed to achieve 180° at the unity-gain frequency.*

achieve unity gain at the frequency where the phase of the open-loop frequency response equals 180° as it crosses the negative real axis (**Fig 8**). Simply stated, the gain margin is the additional gain required to place a closed-loop pole on the jω axis (GH(jω)=−1) and produce instability.

Gain margin alone is not sufficient for you to determine how close GH(jω) is to the −1 point and, therefore, how close a closed-loop pole is to the jω axis, as **Fig** 8 shows. You also need to use phase margin, which is the additional phase shift required to achieve 180° of phase shift at the highest frequency at which the open-loop gain is unity. Typical target values are a gain margin of not less than two (6 dB) and a phase margin of not less than 30°.

The Nyquist diagram is a powerful tool for analyzing all types of systems, but it is not without shortcomings. Its primary limitation is that it lacks a convenient graphical technique that you can use to predict how changes in the system will affect the open-loop frequency response. Any time the system is changed, you must remeasure the response or recalculate it from your system's model. Bode developed a diagram that alleviates this problem.

The Bode diagram (**Fig 9**) is also a plot of the open-loop frequency response, except that Bode treated gain and phase separately, plotting each as a function of frequency (ω). This technique has several advantages for the designer who must evaluate systems while developing them.

By expressing gain in logarithmic units (dB) and phase in degrees, the Bode diagram allows you to combine new data with already established measurements through simple addition. The resulting trace is equivalent to the frequency response you would obtain by connecting the actual devices in cascade and physically measuring the composite.

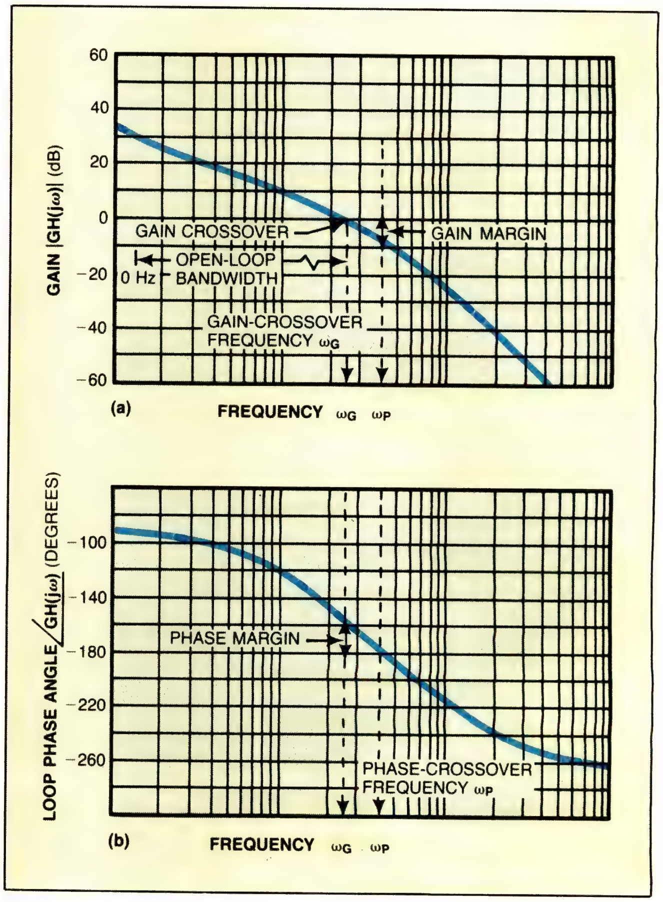


Fig 9—A Bode plot yields gain and phase margin and bandwidth. *The open-loop bandwidth is defined here as the frequency at which the system has unity gain.*

Because of certain techniques that Bode developed, engineers could sketch an approximation of a device's frequency response from its transfer function—ie, they could evaluate GH(jω) over a range of frequencies from the equation for GH(s)—in a Bode diagram without taking the physical measurements. Designers could also perform the opposite function, that of approximating a transfer function from a measured response. For the first time, engineers could link a system's model to measured data without having to resort to extremely laborious calculations.

Bode plots like the ones in **Fig 9** let you measure a system's gain and phase margins. A third performance parameter, the open-loop bandwidth, is also easy to

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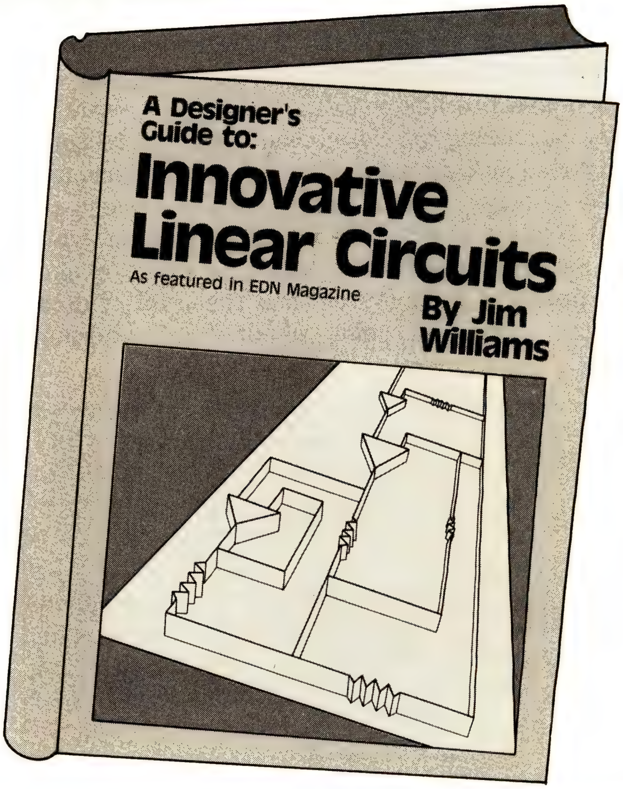

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Graphical-analysis techniques allow you to use a negative-feedback system's open-loop response to predict the system's closed-loop response.

measure on a Bode plot. Open-loop bandwidth indicates how fast a system can react to a change in input; this measurement is analogous to rise time in the time domain. Specifically, open-loop bandwidth is the span between 0 Hz and the frequency at which the open-loop response has unity gain (0 dB). The greater the open-loop bandwidth is, the faster the system will react.

No graphical technique using a Bode plot exists for directly calculating the closed-loop frequency response of unity-feedback systems. Although such a technique (the use of magnitude and phase contours) does exist for the Nyquist diagram, this diagram's linear scales would seldom accommodate both the range of gain values produced by a system and the level of detail about the unity-gain point required to determine stability.

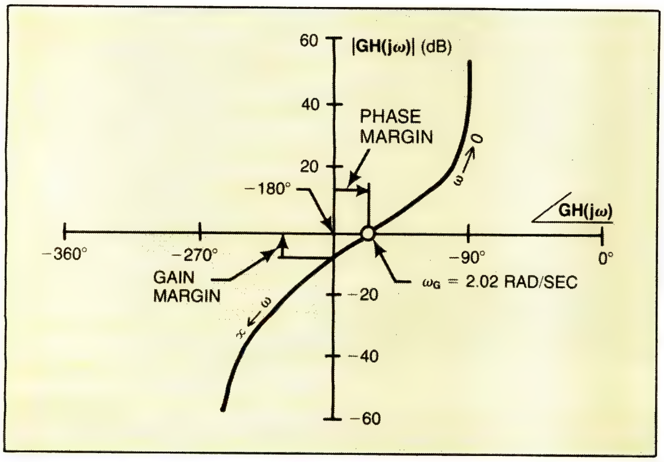
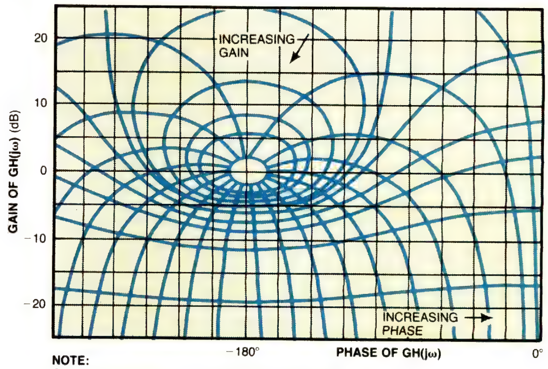


Fig 10—By plotting logarithmic gain against linear phase *in a Nichols diagram, you can calculate graphically a unity-gain system's closed-loop frequency response from the open-loop response.*

The Nichols diagram, a third graphical analysis tool, was developed specifically to accommodate the graphical calculation of the closed-loop frequency response of a unity-feedback system from the system's measured open-loop frequency response. The Nichols diagram uses both the single-plot concept of the Nyquist diagram, in which frequency is a varying parameter (but not a coordinate), and the logarithmic gain and linear phase scales of the Bode plot. Thus, the Nichols diagram is a plot of logarithmic gain versus linear phase as a function of frequency, as **Fig 10** shows.

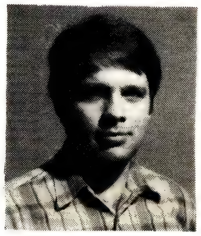
Because of the wide range of gains represented by the logarithmic scale, however, the open-loop frequency response of almost any system could be plotted on a standardized grid. It was practical, therefore, to superimpose a second grid (of magnitude and phase contours) on the Nichols diagram for calculating the closed-loop frequency response. The resulting Nichols chart **(Fig 11)** rapidly became a standard graphical tool for quickly estimating the closed-loop frequency response of a unity-feedback system. Unfortunately, like the Nyquist diagram, the Nichols chart doesn't make it easy for you to combine frequency responses, nor does it provide graphical tools for linking system models and frequency responses. **EDN**



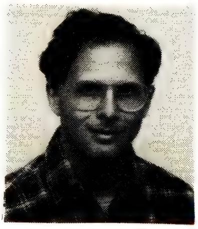
NOTE:
GAIN CONTOURS ENCLOSE CENTER OF CHART.
PHASE CONTOURS EMANATE FROM CENTER OF CHART.

Fig 11—Magnitude and phase contours are superimposed *on a Nichols diagram, forming a Nichols chart. The chart allows you to make a quick estimate of the closed-loop response of a unity-feedback system.*

Authors' biographies



Steven W S Asbjornsen is a product-marketing engineer at Hewlett-Packard (Everett, WA), where he's responsible for control-system application and market development. He received a BSEE from the University of Washington and has been with HP for five years. Steve, who is a musician in his spare time, also enjoys hiking and waterskiing.



Owen Brown, who is in charge of product publicity for Hewlett-Packard (Palo Alto, CA), has worked for HP for two years. He has a bachelor's degree from Yale University and an MBA from the University of Chicago. His spare-time pursuits include painting and aikido.

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TURN TO PAGE 278

64k CMOS E^2PROMS.

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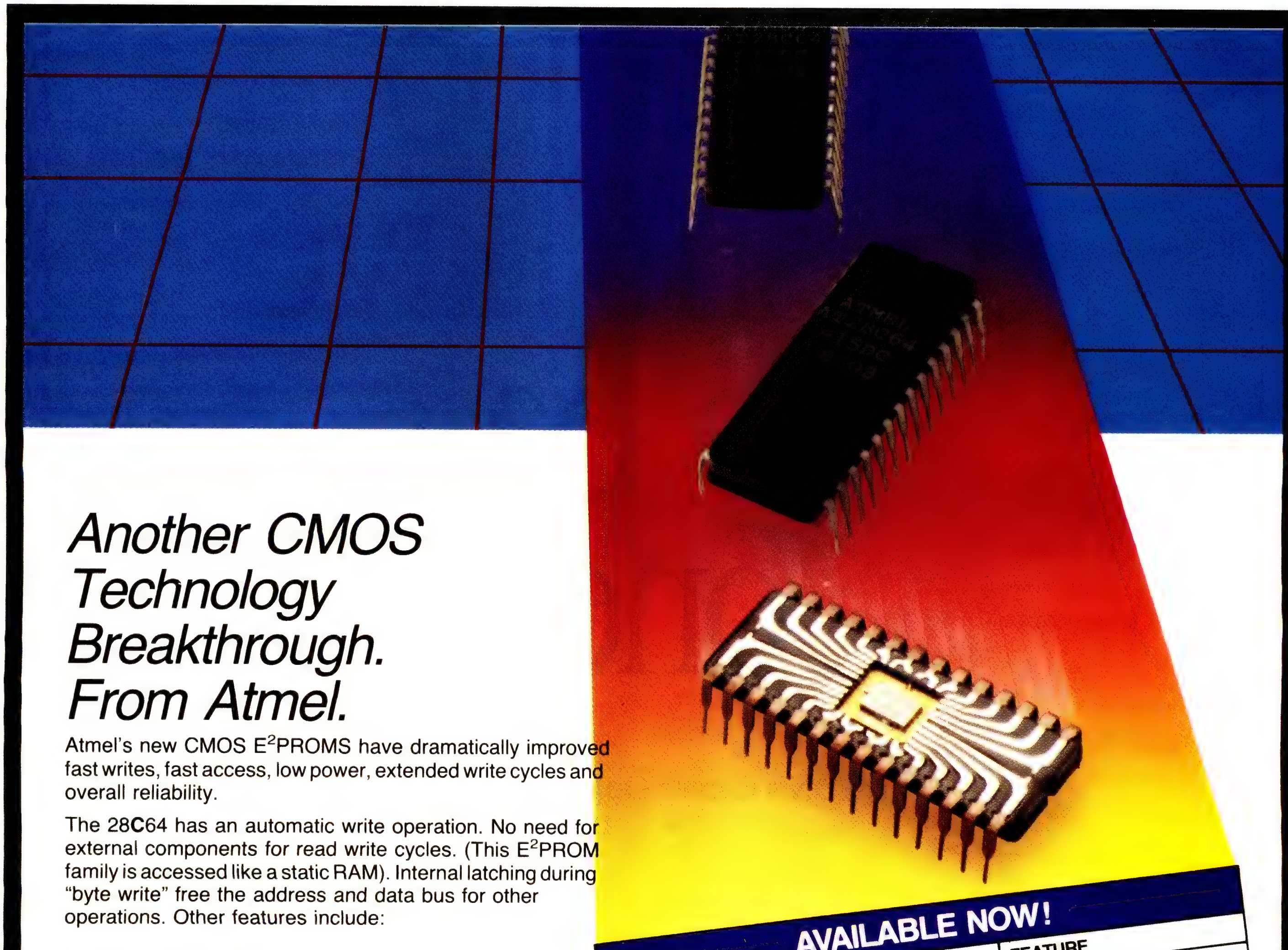

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AT28**C**64E	8k x 8	150-450 ns	200 μs write, 10^5 cycles
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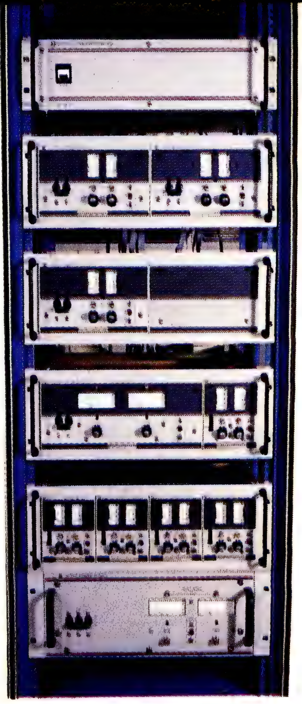

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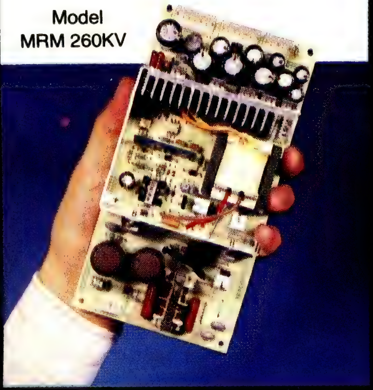

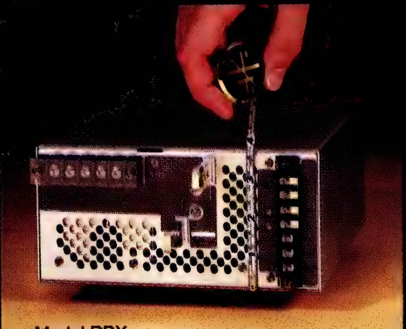

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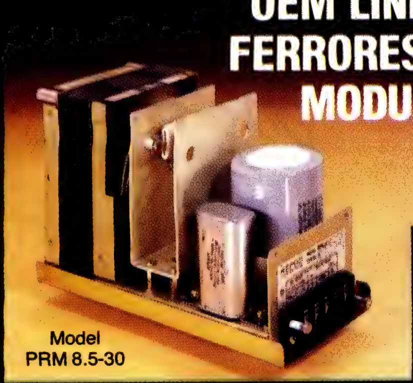

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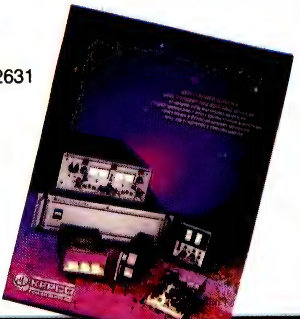

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EDITORIAL

There's still hope, but not much, for our youth

Although we're holding our own right now against foreign gunslingers in the great electronics shootout (from *Metaphors to Provoke Nausea*), the future looks decidedly unrosy. The reason for this pessimistic statement is the growing lack of interest that America's youth is showing in electronics. Consider, by contrast, young people's electronic fervor in Japan. At last count, 1.3 jillion Japanese teenagers were radio amateurs. In the US, we have nine hams who are younger than 93, and two of them are comatose.

If the US is to remain competitive with overseas producers in the near and distant future, what's needed is a crash program to rekindle our young people's interest in electronics. Some ideas:

- Rock-and-rollification of electronics. Imagine, if you will, new songs by such artists as Bruce Springsteen: "Born to Run at 15 MHz" and "Fab'd in the USA"; Twisted Sister: "Smoking in the Class-10 Clean Room"; and David Lee Roth: "Just a Gigahertz."
- Summer camps. I can visualize, for example, a semicustom-IC design camp on Lake Waramaug or a small wafer-fab facility at Camp Okefenokee. The mind reels: Such activities could give rise to fascinating competitive events like propagation-delay races and potato-sack debugging sessions.
- Celebrity endorsements. Picture Mick Jagger in an electronics lab: "Hey, mate—can't get no satisfaction? Time was, I was like you. Got weary of the drugs, booze, and sex, though. Now I'm into electronics, and there's naught groovier. Instead of snortin' now, I get my kicks designin' CMOS gate arrays."
- Financial incentives. Make an engineering career appealing to our youth: Raise engineers' salaries to at least one-tenth those of medical doctors, or one-twentieth those of professional basketball players.

These are just a few possibilities. The definitive solution, of course—one that President Reagan is working on—is to annex every country in the world to the US. This plan, which would make every engineer in the world an American, is meeting with stiff opposition in Congress, because of the thorny issues of polylingual education and trans-Atlantic and trans-Pacific busing of school children. We'd like to receive your feedback on this topic; please use the numbers below to express your opinion.

WJ Travis

Bill Travis
Old Editor

I am against youth.	**Circle No 574**
I am for youth.	**Circle No 575**

NEWS BREAKS SPECIAL SUPPLEMENT

MORE COMPANIES HOP ON NONSOURCING BANDWAGON

Joining the ranks of Standard Pseudocircuits Inc and International Quasiconductor Corp, Lackof Silicon Inc, National Nonconductor Ltd, and Where's the Beef IC Corp have recently become nonproducers of semicustom ICs. Under the terms of the nonsourcing agreement with SPI and IQC, the three new nonproducers agree not to source the semicustom circuits the two original nonmanufacturers are not making. The semicustom circuits the five manufacturers are not producing are drop-out compatible and reflect a noninterchange of technology and masks. Explains SPI's president Jeff Berman, the addition of the three firms to the roll of semicustom-IC nonproducers can only be beneficial because it will further narrow the market for the non-ICs by spreading the common noncustomer base among the five nonmanufacturers.—Bill Travis

RETROACTIVE LAYOFFS IMPROVE COMPANY'S BOTTOM LINE

In a departure from normal industry practice, γ-Ray Corp today announced a plan of retroactive layoffs. Effective immediately, the company is laying off employees who were working for the company as of January 1, 1983, but who subsequently left. Employees retroactively laid off are expected to repay wages and benefits they earned between January 1, 1983, and when they left the company. Current employees aren't affected by the retroactive layoffs. —Jonathan Titus

MEMORY MAKER CUTS PRICES TO BONE

American Process Engineering's president Jerry Fulbright has announced that his company has reached bottom in its learning curve for the production of 64k-byte RAMs. His company's manufacturing process is so efficient, claims Fulbright, that it costs −50¢ to produce each RAM. APE has adjusted its prices accordingly — in OEM quantities, the memories are priced at −25¢ each. Note, however, that customers must pay shipping costs, which are not insignificant because of the weight of the quarter taped to each RAM. The company plans to start shipping 256k-byte units in the second half of 1986; initial price will be 0¢ (OEM qty).—Bill Travis

HARRIS AND RAYTHEON STILL EXCHANGING OBSOLESCENCES

The Harris/Raytheon exchange agreement for obsolete op amps and vacuum tubes recently mourned its third anniversary. According to Harris's Paul Smith, the production ramp-up for 6SN7 dual triodes has reached completion; the company is now producing dozens of the devices per week. What's more, the firm soon plans to announce a shrink version in LCC (lead-crystal case) form. Expect, moreover, a breakthrough in the second half of this year: Harris's mastery of 12.6V-filament technology is almost complete. The company should see first vacuum for a 12SN7 by the third quarter of this year. Results are equally satisfying for Raytheon: The company now has the capability to produce — in volumes of hundreds — the once-industry-standard 709 operational amplifier. —Bill Travis

IBM DISCONTINUES TIMEX/SINCLAIR LOOKALIKE

Industry watchers, listeners, and smellers were stunned last week at IBM's announced withdrawal from the Timex/Sinclair-clone market. Manufacturing of the PCtot by subcontractor Joe's Garage (Sleazonia, WV) will cease by the end of April. According to IBM, however, the cessation of production does not mean the company is abandoning the PCtot. A spokesman said, "We'll continue to market the machine; we're confident that customer demand will remain strong for the dozens of unsold machines in inventory. As for the six people who have already bought PCtots, let me reassure them they'll continue to receive full support from Joe in West Virginia." —Bill Travis

NOISE, NO SIGNALS

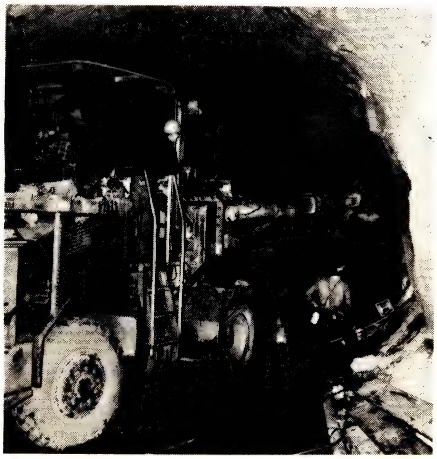
Esaki lives on

Dear Editor:

I'd like to respond to your query, "Whatever became of Esaki and his tunnel diodes that were going to revolutionize computers?" Please refer to the enclosed photograph, taken in White Elephant Electronics' tunnel-diode mine in Montana. White Elephant remains the world's foremost refiner of tunnel diodes. The diodes are used in several unique applications; perhaps the most voracious users are ophthalmologists, who use the devices in the treatment of tunnel vision.

Esakily yours,
George Unidirection

(Ed Note: A 47Ω resistor will probably do the trick, but be sure to separate the whites from the yolks.)



Note the tunneling phenomenon *in this photo depicting the bowels of White Elephant's tunnel-diode mine. After smelting, the diode ore found in this vein will yield 97,413 tunnel diodes.*

Turkey from the Gulch

Dear Editor:

I've noticed that EDN is in the pocket of the Silicon Mafia. When's the last time your magazine published an article on germanium-based integrated circuits? Come on—how much do the silicon moguls and robber barons pay you to keep the wraps on Ge ICs? It's maybe the world's best-kept secret, but here in Germanium Gulch (Sleazonia, WV), we produce more germanium ICs than the White Elephant mine produces tunnel diodes. You should inform your readers that germanium circuits are both faster and less available than silicon ICs.

Yours complainingly,
John Oldfashioned

(Ed Note: We've studied your letter very carefully, Mr Oldfashioned, and we conclude you're a turkey.)

Dear Editor:

You print too many analog-design articles. Nobody reads that stuff anyway. Please forget analog circuits and print more articles about digital circuits.

Sincerely yours,
Tex Tengallon,
Digits-R-Us
Prickly Heat, AZ
(Ed Note: Okay.)

Dear Editor:

You print too many digital-design articles. Nobody reads that stuff anyway. Please forget digital circuits and print more articles about analog circuits.

Sincerely yours,
P Q Warlock
Hocus Pocus Circuits
Research Pentacle Park, RI
(Ed Note: Okay.)

Note to article writers

EDN is always seeking good contributed technical articles. Unfortunately, sometimes submitted material doesn't quite fit in with EDN's applications-article orientation, and it's necessary to send a rejection letter. To ease the gut-wrenching agony of rejection, EDN is adopting the following form letter:

We found your article fascinating, well written and, frankly, hard to put down. A basic problem exists with your material, however: It's so clearly superior to any story we've ever published (or are likely to publish in the conceivable future), that it would probably dissuade other potential writers from even trying to measure up to its excellence. It's with heavy hearts, therefore, that we find ourselves obliged to decline this once-in-a-lifetime masterpiece. We've forwarded your article to the Nobel Committee in Stockholm for consideration. Have you considered changing your name to Hemingway or Faulkner?

Dear Editor:

Although I'm no longer employed as an engineer, I'd appreciate your printing my letter. I used to enjoy reading your magazine.

I was a design engineer at a consumer electronics firm before the company went out of business. When the company went under, some people blamed the Japanese. Some blamed the US government. But neither country is at fault. The real culprits are the yuppies.

Our company sold electronic toys. Then the yuppies—and their kids—started moving into Sleazonia. Suddenly, everybody wanted to be a yuppie.

Before these little yuppies-in-training could sit up, their parents were starting MBA classes in their day-care centers. Now these kids listen to their parents read them *The Wall Street Journal* at bedtime. As soon as these kids can be propped up in front of computers, they'll be cutting their teeth on spreadsheet programs. By the time they're five years old, they'll be doing their parents' taxes for fun.

When will this insanity end? When will kids go back to playing with natural toys like video games and remote-control robots?

Finally, although I don't read your magazine anymore (it's too depressing), I still find it useful in my work.

Sincerely yours,
Poindexter McGuirk
Acme Kennels
Sleazonia, WV

Single-board nuclear reactor supplies standby power for 12 years

Now available on a full-length plug-in card for IBM PC or compatible computers, the QBX-1 add-on nuclear-reactor card provides backup power for as long as 12 years. When the card senses a power failure, explosive bolts eject moderator and control rods from the reactor's interior within 20 µsec, bringing the reactor to its fully rated output of 20 kW in less than a millisecond. Over its 12-year active life, the reactor's power decreases by 25% to 15 kW.

Integral heat fins provide convection cooling of the reactor's 500W power dissipation while the reactor remains in its standby condition. If your computer's fans can't furnish 400 ft^3/sec of forced air for cooling, consider buying the manufacturer's heavy-water cooling jacket and stainless-steel pump module, which fit conveniently under a desk or workbench. Latches on each side of the reactor module let you quickly exchange the radioactive core, should you need to replace it. An optional circular viewing port of lead glass lets you check the reactor's internal mechanical assemblies.

To protect users from undue radiation, each reactor includes a shielding kit comprising five self-stick lead plates and 20 radiation-monitoring film badges. The lead plates mount inside your computer's enclosure and reduce the gamma rays that cause soft errors to floppy-disk and RAM data. For further protection, consider buying the manufacturer's 200-ft extension cords for keyboards and monitors.

Because the reactor can supply more than enough power for your computer, you can sell excess power to your local utility company. An add-on phasing and metering kit (PMK-1) lets you connect your reactor to the local power grid. Each PMK-1 includes standard power-sale contracts and Rural Electrification Board rules and regulations.

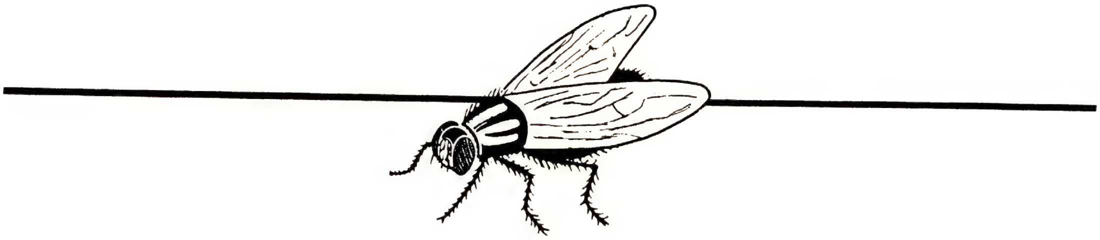
Although not required in all localities, each reactor card package includes a standard 23-volume site-evacuation plan. The plan includes blank forms for you to fill in the name and address of your reactor site and then mail to the Nuclear Regulatory Commission. As an option, the manufacturer supplies the plan on 12 MS-DOS-compatible disks in Wordstar format. User-friendly templates let you type in information so that your word processor can create a complete, printed document.

Reactor prices start at $2.3 million (1). Delivery, seven years ARO.

—***Regus Patoff***

Luminescent Electronic Products Inc, Box U-235, Trinity Site, NM 43210. INQUIRE DIRECT

Nuclear reactor supplies CPU power *during power failure or other power emergencies. The reactor also glows in the dark (as will you), which makes it easy to find your computer.*



Electrode to draw flies, party nuts, and the unemployed

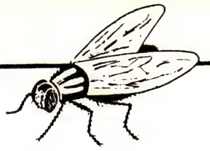
Armed with a list of show vendors who may or may not show up at this year's show, Electrode show sponsors expect the show to outshow all previous shows.

Frances T Granville, *Editor for Show*
Mini-Micro Systems

"Be there, aloha," may well be the theme of this year's Electrode '86 show, but that was not definite at press time, as show sponsors—not determined at press time—tried to decide exact location and dates of the show, neither of which were set at press time. Show sponsors, who were unavailable for comment at press time, will probably be either The American Federation of Hippopotami (AFHIP), The InterNose Group, or Eye Eye Kwadruple E! (EEKE!). Sponsors, whoever they turn out to be, expect the show to be held sometime this year in Anaheim, Atlanta, Chicago, Washington, San Francisco, or all five on a round-robin basis.

Expanding on the "aloha" theme, show spokesperson R Roland Roland, who was unavailable at press time, states, "Originally, we thought the show would be held in Honolulu, but that was not set at press time, so we had to set our sights on other sites." The sponsors expect the show to attract "anywhere from" 50 to 1 million attendees and one to 500,000 exhibitors. Attendees should come from Fortune 5000 companies or from the Salvation Army Shelter, depending on the show's location. Attendees are expected to include corporate end users, meter maids, industry spokesmen, industry spokeswomen, supermarket checkout clerks, chefs, policemen, trade-press editors, account executives, and the like.

Industry gurus, pundits, fortunetellers, gypsies, and palm readers agreed at press time that it would be difficult to predict whether Electrode would be held at all. But all believe that many a would-be attendee will find himself or herself sticking a toe into uncharted



waters while simultaneously jumping on the OEM bandwagon. Furthermore, many add, we all know just how painful that can be.

What's more, industry mystics comment, exhibitors may or may not display such products as various op amps, including bop amps, amp ops, oops! amps, and whoops! amps; several fiber-optic linkers, blinkers, and clinkers; MOSFETs, FETMOSS, peat moss, CMOS, and sea moss; ICs and ICKs; FIFOs and FIDOs; minicomputers; extremely loco area networks (ELANs); add-on/add-ins and subtract-off/subtract-outs; steel-wool pads; soap; oatmeal; mouthwash; deodorant; toothpaste; keyboards; pianos; peripherals; periwinkles; sweaters; dresses; jewelry; lingerie; menswear; foundation garments; and a host of other products guaranteed to catch the eye—and nose—of even the most jaded would-be show attendee, if, in fact, any do show up.

Many lucky attendees may or may not win door prizes, which might be a complete facial and makeover on the mezzanine; a trip for two to the Bahamas; or a cup of coffee. A bridal show will take place on Monday, followed by the East Overshoe, ME, Junior League's rendition of "South Pacific." A bake sale in the lobby will end the festivities, if, indeed, they do take place.

Electrode might be unbeatable for showing what's new and newsworthy, according to many industry oracles. "We may announce a product at the show, but then again, we may not," comments a company spokeswoman, who asks that neither she nor her company be named. "If we do, and you don't attend the show, you most likely won't see it," she quips cryptically. "Then again, if we do show up and you don't, then you missed us."

Joseph Schmoe, of CPU Bored Corp, Molehill View, CA, agrees: "We'll either announce something or not," he states unequivocally. "We may exhibit or not. Come by my office a week from next Tuesday, and if a Rent-A-Truck is parked outside, along with our equipment to be moved to the show, then I guess we'll be there."

Bud Smith, vice president of semis for a major semiconductor manufacturer, also doesn't know whether his company will be at Electrode. "At first, we decided to exhibit," says Smith, "but if Joe [Schmoe] won't go, then neither will I."

General consensus among industry spectators, onlookers, lookers-on, passersby, and night watchmen seems to be the same: Schmoe probably won't go to Electrode. "He'd be a little fish in a big pond," states one observer. Another spectator counters, "I personally, from my own viewpoint, believe that we'll all be big fish in a little pond." And, quips a third, "This show may have several OEMs parking their new disk drives in the OEM disk-drive garage, and those drives are sure to have all the dimensions of a Mack truck." Asked what, exactly, those dimensions were, the analyst stated, "They're growing like gangbusters."

Among those companies that have definite plans to exhibit, although no one was really sure at press time, is Bright-O, a Fortune 1000 steel-wool-pad maker in East Overshoe, ME. The pads, designated the 520520025125ABC-D0612502 Series, reportedly clean pots, pans, and fiber-optic cables to the tune of 1.522M bps. "That's the fastest rate in the industry," opines Obie Bright, marketing communications manager at Bright-O. The company plans to demonstrate the aforementioned zippy pads in a multivendor, on-line, internetworking, high-speed, fiber-optic display with at least 299 other vendors or whichever vendors happen to show up.

Another company, Dentu-Cleanse of Moline, IL, may or may not exhibit its long-lasting denture glue, which transmits as many as eight rock 'n' roll tunes at 19 MHz through the denture wearer's mouth over a single "twister"-pair cable. "Auntie Em, it's a twister!" exclaims Kansas resident Dorothy Gale, who was, unfortunately, available for comment at press time.

The show may or may not feature several technical sessions interspersed with several lively or dull round-robin discussions, perhaps including "If You Missed the STD Bus, Take the A Train," "Byte vs Bight: Industry Standards Makers Hammer out Standard Spellings," "Breadboxes: the Breadboards of the '80s?" and "CAD/CAE: Exploring Trends in Computer-Aided Dieting/Eating." **EDN**

Author's biography

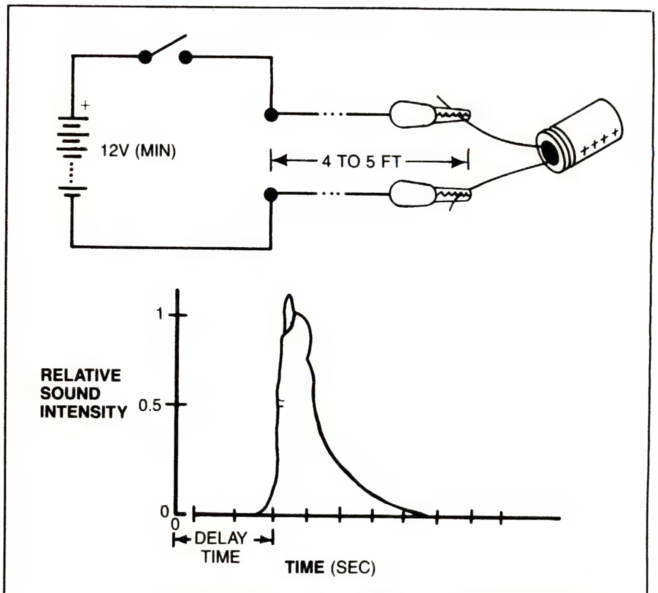
Frances T Granville, who was unavailable for comment at press time, may or may not be an associate editor at Mini-Micro Systems *magazine. Probably a graduate of some college or university, Granville most likely has a degree. Her hobbies may or not include jogging, backpacking, chess, stamp collecting, tennis, aerobics, raquetball, karate, swimming, cross-country skiing, music, reading, collecting antique scientific instruments, and driving locomotives down abandoned railroad tracks.*

Exploding capacitor is one-shot noise source

Jonathan Titus
Demolition Editor

By back biasing an electrolytic capacitor with a dc power source **(Fig 1)**, you'll form a one-shot noise source. Unlike back-biased diodes that furnish a broad spectrum of electrical noise, the capacitor provides a burst of noise across the audio-frequency spectrum without requiring an amplifier. Because each capacitor provides only a single burst of noise, you'll need a large supply of capacitors for repetitive noise bursts. Aluminum electrolytic capacitors provide the best burst response. Use the noise source with caution—it's a radiation hazard. Bursts of metal and plastic fallout accompany each noise burst.

Note that you can use back-biased electrolytic capacitors in applications other than noise-burst generation. If you tape a capacitor to each cockroach infesting your house, for example, you'll have a very effective extermination system **(Fig 2a)**. In another application, inserting a capacitor in your sink or bathtub drain can relieve clogging; in a related application, the devices can unclog stuffy sinuses **(Fig 2b)**.



NOTE: DELAY TIME DEPENDS ON CAPACITOR VALUE.

***Fig 1—Indulge your penchant for destruction** with this easy-to-build noise (and shrapnel) generator. Close the switch and your eyes, and enjoy the loud SNAP that precedes the pain from the lacerations. To reset the circuit, rebuild it.*

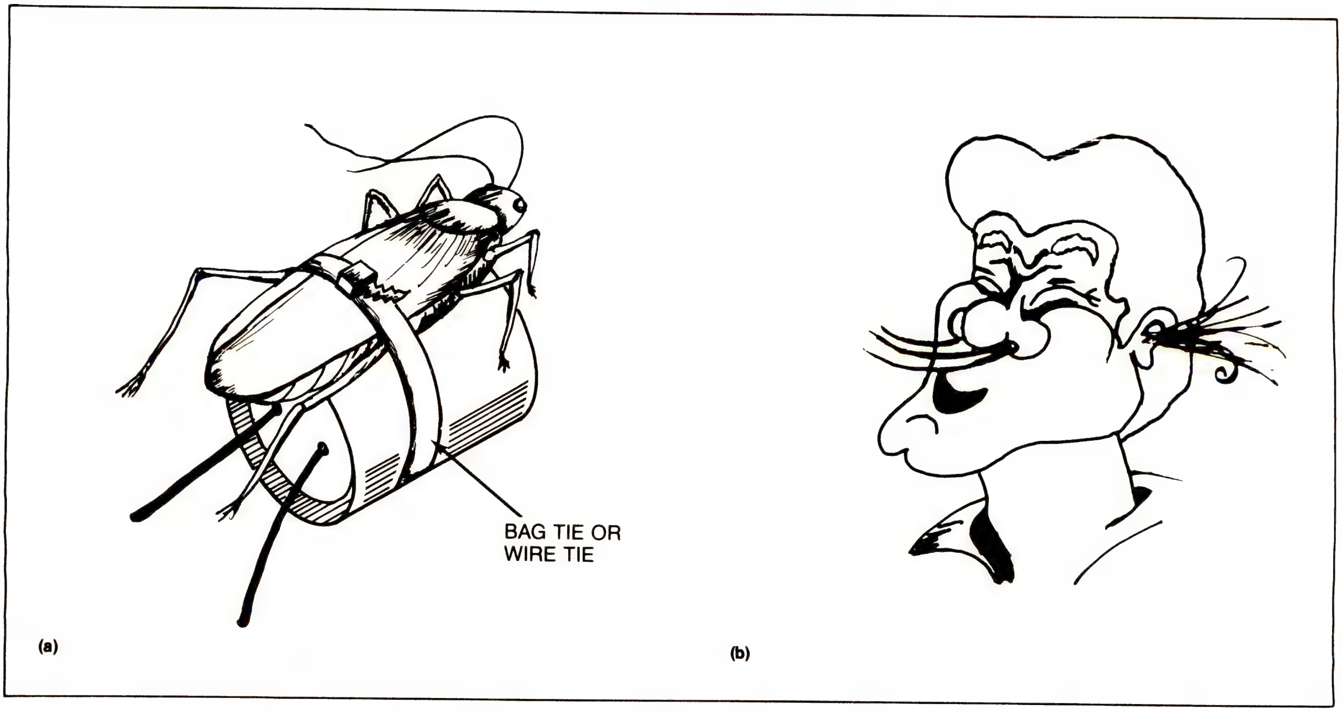

BAG TIE OR WIRE TIE
(a)
(b)

***Fig 2—Destruction can be useful,** as seen in these applications for exploding capacitors. One unit taped to every cockroach **(a)** can rid your home of these pests. The bursting capacitors also make very effective sinus-cleaner-outers **(b)**.*

LOOKING AHEAD SPECIAL SUPPLEMENT

RELUCTANTLY WRITTEN BY GEORGE STUBBS

Many public officials to be robots by '88

In the waning months of the Reagan Administration's tenure, members of the press and viewers of C-Span will bear witness to a subtle but fundamental change in the face the US government presents to the people. "That's because many public officials will be robots," said a White House aide, who refused to reveal his or her or its name over the phone. "I mean it this time. Literally. You know: electronic circuits, artificial-intelligence programming, sensory transducers—honest-to-goodness androids. None of that 'Danger danger,' Lost in Space malarkey."

The radical measure is a response to the problem of retaining talented administrators in the halls of public service, a particularly vexing problem for this administration. Alexander Haig, Michael Deaver, David Stockman, John Block—not since the days of the Truman administration has there been such an exodus of high-level officials, who escape to the private sector and the allure of six-figure salaries. To address this problem, the National Academy of Sciences has funded secret research that has applied the latest in computer technology to create the perfect, devoted public servant.

"We need public servants who will not waver in terms of national loyalty and job dedication," reported the source, who wouldn't even give his or her or its initials. "We expect to have robots performing at a variety of levels very soon—at the White House, at the State Department, at the Pentagon, and in a variety of other executive-branch positions.

"Many of the functions of the State Department will be easy to implement. Press-liaison tasks could be easily handled by a simple robot that issues such familiar canned responses as 'We are in touch with the embassy,' 'You gentlemen have all the information we have,' and 'We are not prepared to make a statement at this point in time.'"

The source, who would not provide a phone number so that we could ask him or her or it some follow-up questions later, also revealed that two prototypes have actually been in operation for some time. "One prototype shows a persistent malfunction in its sentence-construction subroutine. Actually, millions of citizens were witness to one of the worst episodes of that bug, during the Vice-Presidential debates of 1984."

"The other prototype has fared somewhat better. Though its normal behavior is rather formal, stiff, and even downright soporific, it surprisingly showed something akin to rage on a couple of occasions—most notably when the President proposed that all government officials take lie-detector tests."

US to relieve trade woes by annexing Japan

In an attempt to relieve the misery of its current trade imbalance with Japan, the United States will, in 1987, annex the land of the rising sun, reports Salvatore Vitelli, next-door neighbor of this reporter. By making Japan the 51st state, the US will turn a crippling, billion-dollar trade deficit into an immediate, reviving boost to its Gross National Product, and it will once again become the dominant force in world markets. According to Vitelli, the first moves toward alleviating the trade situation will occur in mid-1986, when cabinet members will hammer out a bold proposal to sell Hawaii to Japan.

Widespread protests in the nation's only island state will effectively kill the plan, but similar proposals will be considered—some involving California and a few atolls under US jurisdiction. Then, sometime in early 1987, says Vitelli, Secretary of Labor William Brock (former Secretary of Trade) will burst in on a cabinet meeting and detail the annexation bid. Ronald Reagan will wake up in time to hear the words "creating a new base of investment and taxes that will eliminate a significant portion of our national debt" and give his approval to the measure.

"It's amazing no one ever thought of it before," Brock will say. "Congress will no longer have to waste the taxpayers' money stumping for disastrous protectionist legislation. It's good for everyone, all the way around." "We conquered them once," Brock will continue, "and now that the best-established military presence in Japan is ours anyway, it should be a piece of cake to do it again. Just a paper exercise, I should think."

OCCASIONALLY, EVERYONE WISHES HE HAD ANOTHER SHOT AT HIS DESIGN.

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Part Number	Array Size	Max Pins	Gate Length	Gate Delay (ns) [1]	
				TYP	MAX [2]
TC15G008	880	74	3	2.5	5.0
TC15G014	1400	92	3	2.5	5.0
TC15G022	2200	114	3	2.5	5.0
TC15G032	3200	138	3	2.5	5.0
TC15G042	4200	156	3	2.5	5.0
TC15G060	6000	180	3	2.5	5.0
TC17G005	540	44 48	2	1.5	3.0
TC17G008	880	52 68	2	1.5	3.0
TC17G014	1400	68 86	2	1.5	3.0
TC17G022	2200	82 106	2	1.5	3.0
TC17G032	3200	98 128	2	1.5	3.0
TC17G042	4200	118 150	2	1.5	3.0
TC17G060	6000	146 188	2	1.5	3.0
TC17G080	8000	174 222	2	1.5	3.0
TC17G100	10000	180 232	2	1.5	3.0

NOTES:

[1] For a 2 input NAND gate having a fan out of 2 and 2mm of metal interconnect.

[2] At 70°C and Vdd = 5v ± 5%

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DESIGN IDEAS

EDITED BY TARLTON FLEMING

Feedforward amplifier reduces distortion

Michael Ellis
Scientific Atlanta, Norcross, GA

You can employ feedforward techniques to reduce distortion in wideband RF amplifiers; the audio amplifier in **Fig 1** illustrates the feedforward principle, even though feedforward techniques offer no significant advantage in the audio-frequency range. (Both feedforward and feedback techniques reduce distortion in amplifiers, but each approach carries a distinct penalty. Feedback loops are subject to instability, whereas feedforward amplifiers are inherently stable but require an additional error amplifier.)

In **Fig 1**, the main amplifier has a gain of 10, but it introduces some distortion (D) in the amplification process. This component appears at the error amplifier's output (−D), but the signal components cancel at that amplifier's summing junction. In turn, the distortion component cancels in the output voltage divider, leaving the desired output of $-10V_{IN}$.

The feedforward technique allows amplification at RF frequencies without stability problems. In an RF amplifier, a directional coupler replaces the output 10-kΩ/10-kΩ divider. The coupler cancels the distortion while maintaining a 50Ω (or 75Ω) output impedance. CATV amplifiers use feedforward techniques, for example, to transmit 60 TV channels (54 to 450 MHz and higher) for 30 miles. **EDN**

To Vote For This Design, Circle No 746

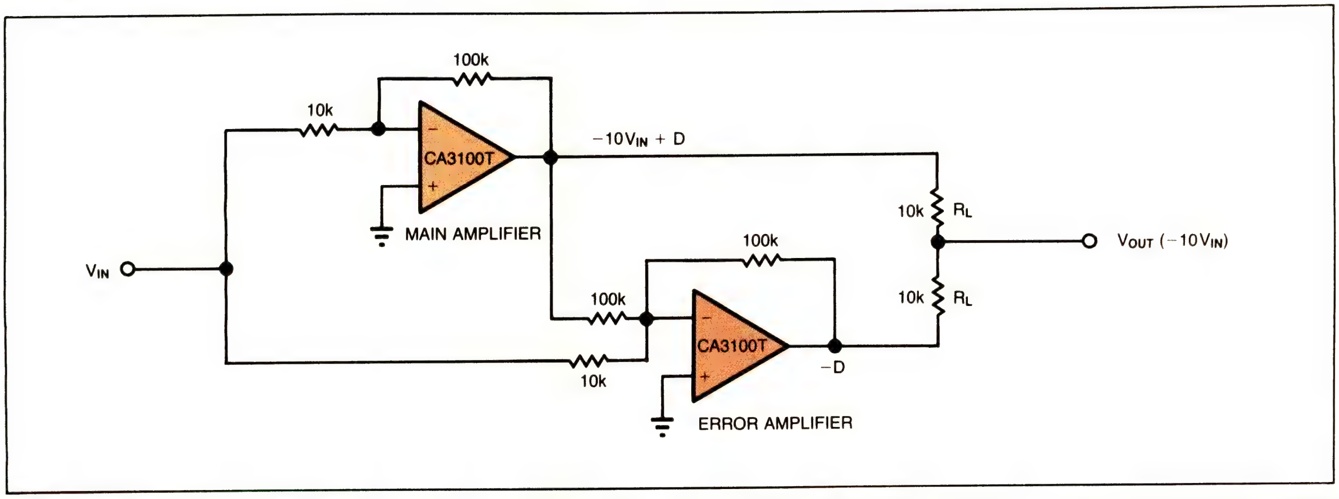


***Fig 1—A feedforward error amplifier** provides cancellation of the main amplifier's distortion products (D) while preserving the desired ($-10V_{IN}$) output.*

ECL IC forms high-speed oscillator

M U Khan
Systronics, Ahmedabad, India

Using a quad line-receiver IC **(Fig 1)**, you can build a gated oscillator that produces a square-wave output with a 20-Hz to 220-MHz frequency range. The ECL device also provides balanced or unbalanced (single-ended) outputs, and it allows for synchronous gating of the oscillator output **(Fig 2)**.

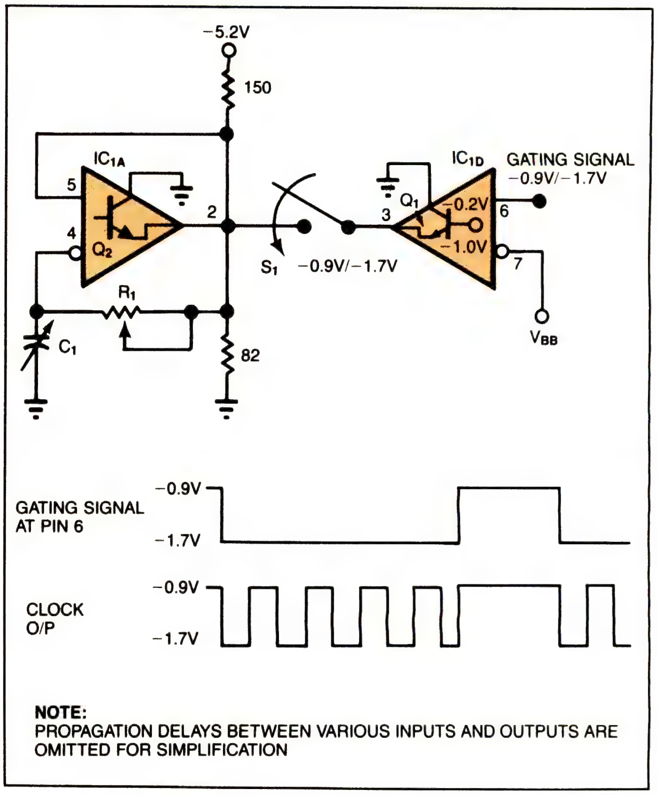
In **Fig 1**, IC_{1A} is configured as a Schmitt-trigger-type astable multivibrator, in which R_1 and C_1 determine the frequency. IC_{1A}'s output connects to the noninverting and inverting inputs, respectively, of IC_{1B} and IC_{1C}. The other inputs of IC_{1B} and IC_{1C} connect to the IC's reference voltage V_{BB} (pin 9). Thus, the outputs of IC_{1B} and IC_{1C} provide single-ended CLOCK and $\overline{\text{CLOCK}}$ signals, and these outputs together provide a balanced differential clock signal. When S_1 is open, R_1 and C_1 determine the oscillator's frequency.

With S_1 closed, IC_{1D}'s output controls the oscillator: An ECL logic 0 level (approximately −1.7V) allows the oscillator to run, and a logic 1 level (approximately −0.9V) inhibits the oscillator's operation. IC_{1D} accepts either balanced or single-ended gating signals (for single-ended operation, remove R_2 and connect the noninverting input to V_{BB}). In either case, an ECL logic 1 level at pin 6 turns the oscillator off, and the IC_{1A} output always stops at the logic 1 level. **EDN**

References

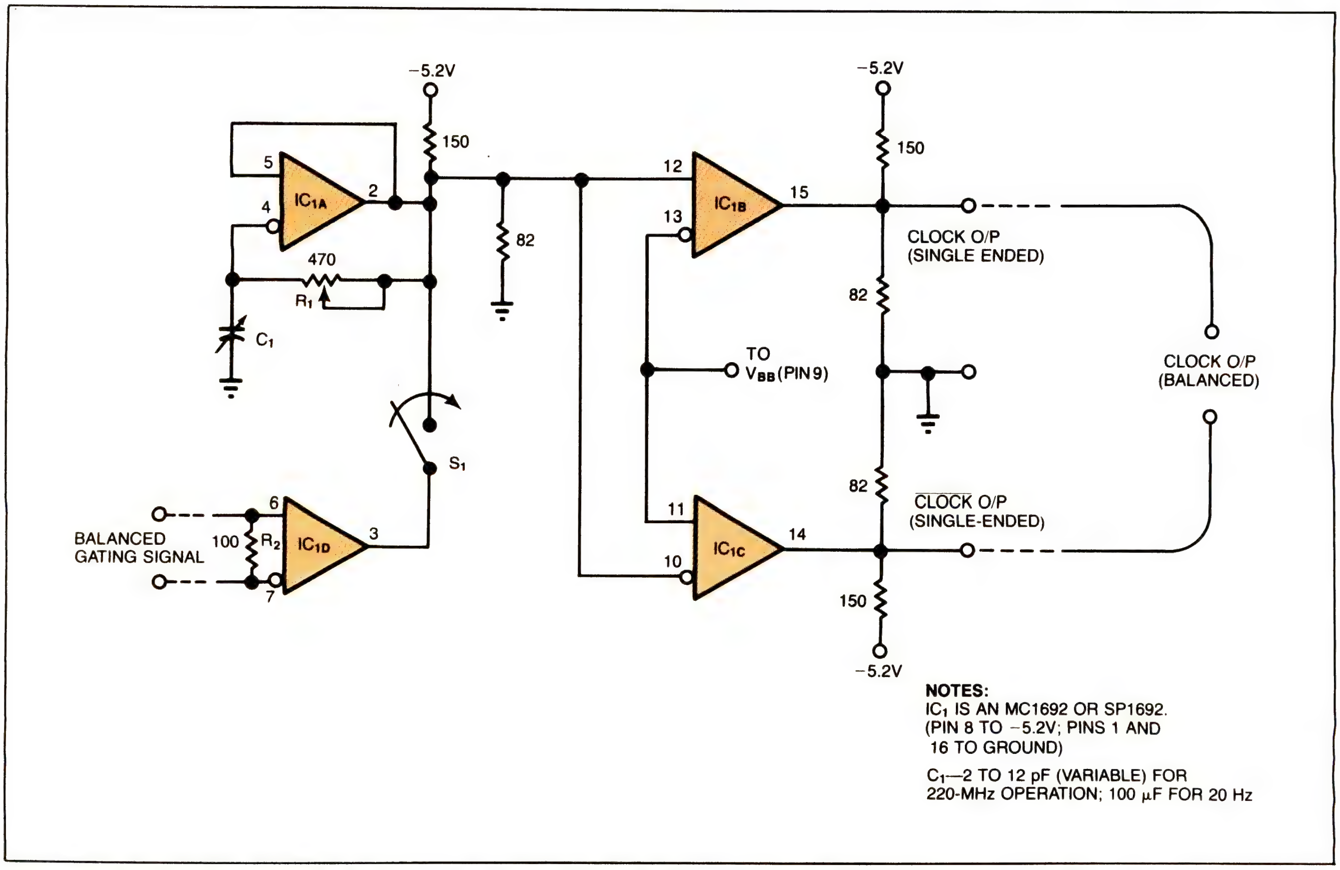
1. Khan, M U, "Two-chip pulse generator operates at 75 MHz," *Electronics*, March 24, 1981, pg 139.
2. Trimble, Donald, "Build a 1-chip, 300-MHz gateable oscillator," *EDN*, April 4, 1985, pg 269.

To Vote For This Design, Circle No 749



NOTE:
PROPAGATION DELAYS BETWEEN VARIOUS INPUTS AND OUTPUTS ARE OMITTED FOR SIMPLIFICATION

*Fig 2—**With S_1 closed,** transistor Q_1's emitter assumes an ECL logic 0 level to allow the **Fig 1** oscillator to run; conversely, the oscillator turns off when the emitter assumes the logic 1 level.*



NOTES:
IC_1 IS AN MC1692 OR SP1692. (PIN 8 TO −5.2V; PINS 1 AND 16 TO GROUND)

C_1—2 TO 12 pF (VARIABLE) FOR 220-MHz OPERATION; 100 µF FOR 20 Hz

*Fig 1—**You can set this oscillator's frequency** from 20 Hz to 220 MHz and turn it off or on with an external ECL signal.*

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C-program input functions are user friendly

Odd Arild Olsen
Norwegian Institute of Technology, Trondheim, Norway

The Getcom program (**Listing 1**) provides an alternative to menu selection as a means of entering commands in a C program. Getcom lets you avoid the unwelcome pauses associated with a menu system as well as the inconvenience of having your display disappear when the menu appears.

LISTING 1

```
/**** G E T C O M ****/

main()
    {     /* example of command record and calling GETCOM */
    int comnr, def, level;
    char text[20];
    static char *com[]= /* array of legal commands, each less then 19 chrs */
        {
        "read-file",            /* 0 */
        "write-file",           /* 1 */
        "delete-file",          /* 2 */
        "init-parametr-file",   /* 3 */
        "init-data-file",       /* 4 */
        "exit",                 /* 5 */
        "."                     /* '.' is the end-of-record mark */
        };
    level= 0;                    /* printout starts at left margin */
    def= 3;                      /* default command is "init-parametr-file" */
    strcpy(text,"file operation");
    while(1)
        {
        comnr= getcom(com, def, text, level);
        printf("\n\ncommand accepted: %s",com[comnr]);
        }
    }

getcom(com, def, text, level) int def, level; char *com[], *text;
    /* com   : pointer to command array
       def   : default command number
       text  : printed to advice operator
       level : number of spaces to indent printout     */
    {
    char in[19], *ptr;             /* input <= 18 chars */
    int dots, i, match;
    while(1)
        {
        printf("\n");
        for( i=0; i<level; i++) printf(" ");
        printf("%s", text);
        dots=55 - (strlen(com[def]) + strlen(text) + level);
        for( i=0; i<dots; i++) printf(".");
        printf("( ");
        printf("%s",com[def]);
        printf(" ): ");
        scanf("%18s",in);
        if(!strlen(in)) return(def); /* CR returns default */
        ptr= in;
```

Continued on pg 204

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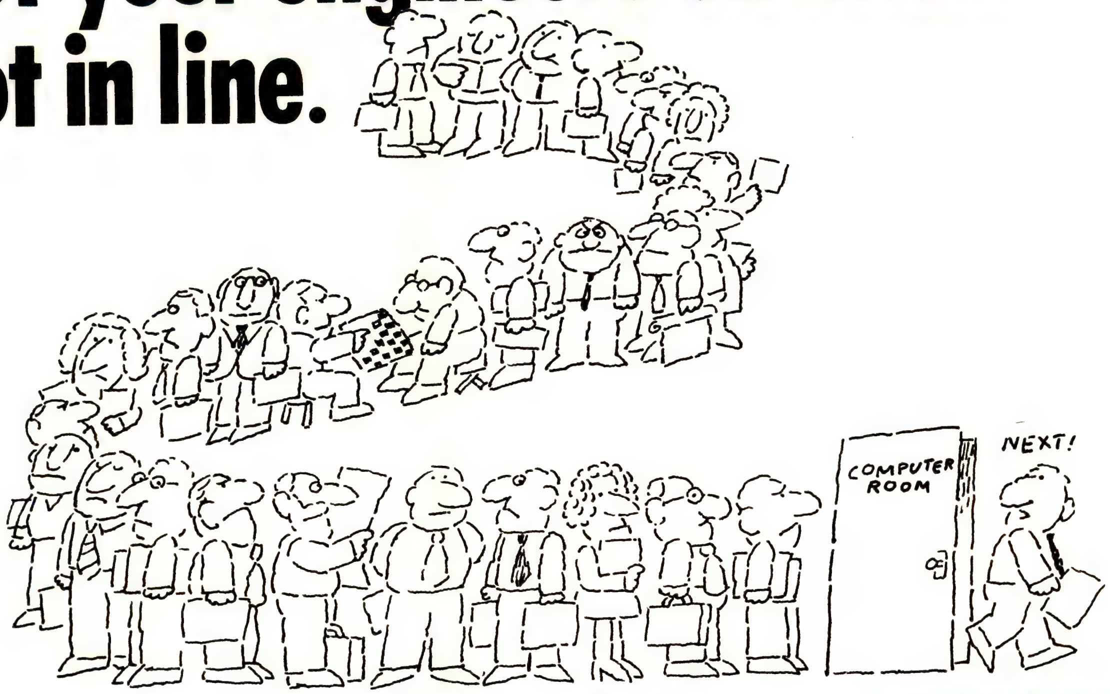
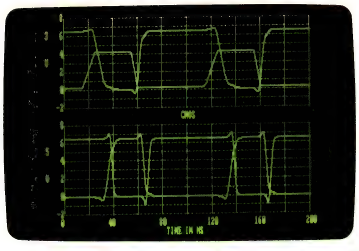
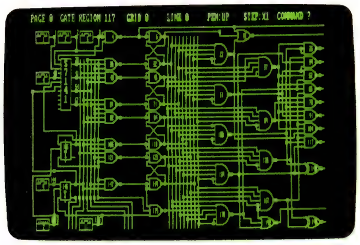




"Typical MICROCAP Transient Analysis"


PAGE 0 GATE REGION 117 GRID 0 LINE 0 PEN:HP STEP:X1 COMMAND ?

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CIRCLE NO 93

Getcom lets you type the commands as character strings. Commands can consist of several hyphenated words. You can abbreviate each word to varying lengths, and you can even abbreviate a word by using just the first letter, provided no other legal command begins with the same letter. If you do enter an ambiguous command, the program will present a menu of the legal commands. Thus, an inexperienced user can deliberately call up the menu by typing an illegal command (a space, for example). **EDN**

To Vote For This Design, Circle No 748

Continued from pg 202

```
    while( *ptr= tolower(*ptr)) ++ptr;
    match= compcom(com, in);
    if( match < 0 ) { helpcom(com); continue;}
               /* try again if ambiguous or not legal */
    else break;
    }
return match;        /* command number */
}
compcom(k, in) char *k[],*in;
    /* compares given command with legal commands */
    {
    int i, match, numbm;
    i= numbm= match= 0;
    while(*k[i] != '.' )
        {
        if( comp( k[i], in)) { match=i; numbm++;}
        i++;
        }
    if(numbm == 1 ) return match; /* one match: accept */
    return -1;                    /* ambiguous or illegal command */
    }

comp(pm,pi) char *pm, *pi;
    /* compares the input-string pi against the template pm */
    /* returns 1 if match, otherwise 0
    /* 'm'-pointers are template related
    /* 'i'-pointers are input related
    {
    char km[20], *ptrm, *ptri;
    ptrm=km; ptri= pi;
    *ptrm= 0;
    while(*pi )
        {
        if(*pi== '-') while( (*pm != '-' ) && (*pm)) ++pm;
                 /*truncate template to end or next '-' */
        *pi++;
        *ptrm++= *pm++;
        }
    *ptrm = 0;
    if(!strcmp(ptri, km)) return 1;
    return 0;
    }


helpcom(com) char *com[];
    /* prints the legal commands */
    {
    int i;
    i=0;
    while(*com[i] != '.' ) printf("\n %s",com[i++]);
    printf("\n");
    }
```

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Memory mapping reduces component count

Robert A Dougherty
Consultant, Palm Harbor, FL

Consider a system whose CPU must write 16-bit control words into 50 hardware registers (each of which requires two 54ALS374s, for a total of 100 DIPs). Several schemes can be used to later modify individual bits of this data—without disturbing the other bits. One approach is to accept the software burden of maintaining an image file of the data in memory. Another approach is to provide a means for reading back the hardware-register contents by adding another 100 DIPs (54ALS244s) to the machine.

A third, and better, approach is to store the hardware-register contents directly in the CPU's memory space, so the image file in RAM and the 50 control registers are in the same software locations. When the system accesses a register for a write operation, it stores the data simultaneously in the RAM and in the hardware register. For a read operation, it can only read the data from RAM because the hardware lacks read circuitry and is unable to respond. Consequently, you can use the CPU's bit-operation instructions, and hardware is kept to a minimum.

Note that the system's assembler or compiler must know exactly where the registers are located in its memory space, and it must place the image file in the same space (most assemblers and compilers have this feature). Note also that if the system makes an error when writing to a 54ALS374, you have no guarantee that the registers and memory contain the same data. **EDN**

To Vote For This Design, Circle No 750

Transducer improves ultrasonic ranging

Mitchell Lee
National Semiconductor, Santa Clara, CA

In an ultrasonic ranging system, a single transducer often does double duty: First, it behaves like a loudspeaker while generating the transmit pulse; then—ideally—it immediately stops ringing and behaves like a microphone while listening for the return echo. Piezo-

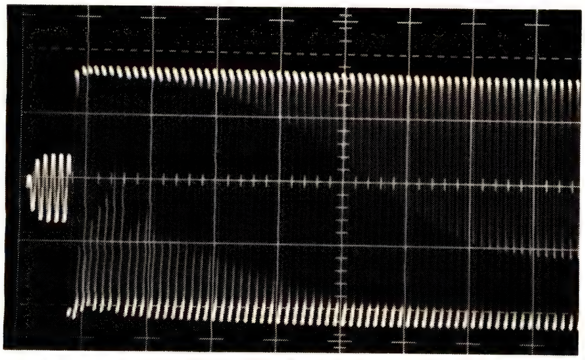

Fig 1—The ringing that follows excitation *of a piezoelectric transducer can last for 20 msec, masking the echoes from targets within 10 ft of the transmitter. In this photo, scale is 5V/div in the vertical axis and 200 μsec/div in the horizontal axis.*

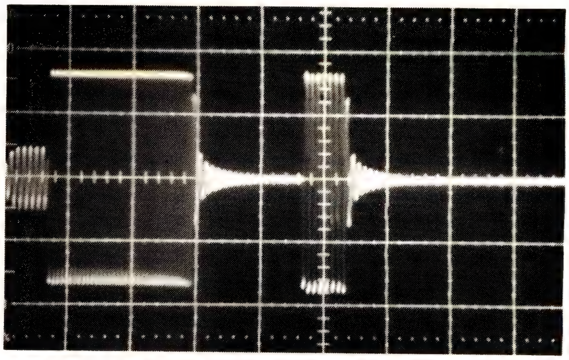

Fig 2—Ring duration for an electrostatic transducer *is less than ½0th that of a piezoelectric type, allowing easy recognition of an echo that occurs 800 μsec after the transmit pulse begins. Here, scale is 5V/div in the vertical axis and 200 μsec/div in the horizontal axis.*

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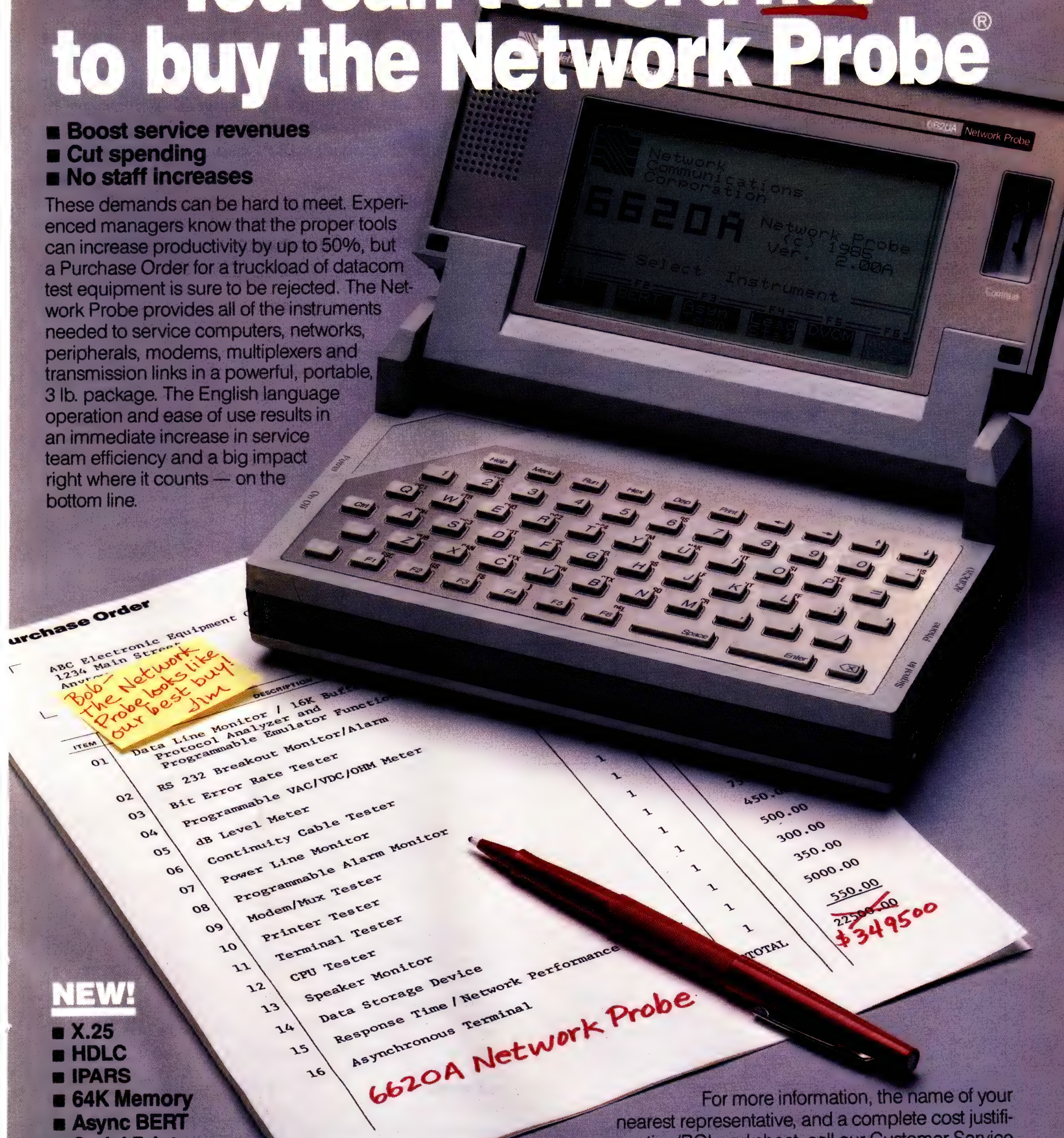

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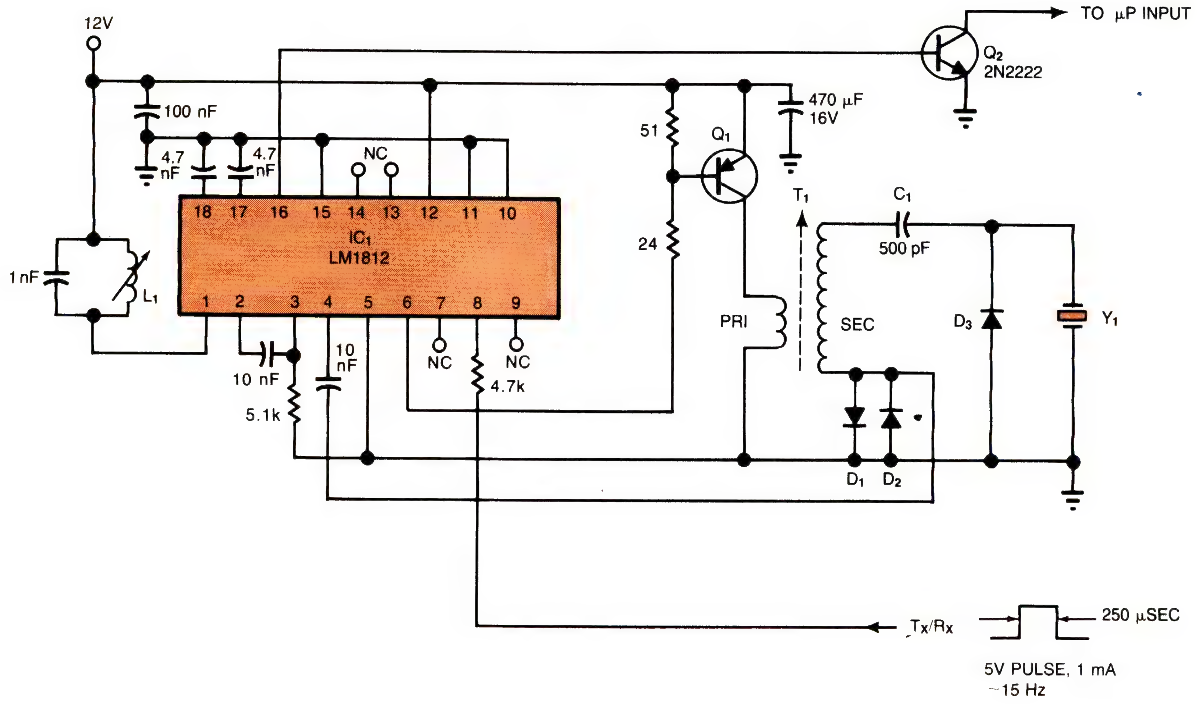
CIRCLE NO 94

electric transducers, however, have a high Q and can continue to ring for 20 msec or more after excitation has ceased, thus masking return echoes representing more than 10 feet of range **(Fig 1)**.

Broadband electrostatic transducers, however, lower the minimum range by reducing the ring time **(Fig 2)**. You can combine an electrostatic transducer with an ultrasonic transceiver IC **(Fig 3)** to build a ranging system that senses objects at distances from 4 in. to more than 30 feet.

Transducer Y_1's broadband characteristic simplifies tuning. The secondary of T_1 resonates with the 500-pF capacitor C_1 at a frequency between 50 and 60 kHz. You tune L_1 to this frequency by using an oscilloscope to note the maximum echo sensitivity at pin 1. Step-up transformer T_1 provides 150V bias for the transducer. **EDN**

To Vote For This Design, Circle No 747



PART	PARTS LIST DESCRIPTION	MANUFACTURER
L_1	15.8 mH ADJUSTABLE #CLN-2A900HM	TOKO AMERICA (SKOKIE, IL)
T_1	PRIMARY 8 TURNS #24* SECONDARY 110 TURNS #30* POTCORE RM8P-A630-3B7 BOBBIN RM8 PCB1-4 CLIPS 991-393-00	FERROXCUBE (SAUGERTIES, NY)
X_1	TRANSDUCER	POLAROID (CAMBRIDGE, MA)
Q_1	D45C6 I_C = 5A MIN; V_{CBO} = 40V MIN	NATIONAL SEMICONDUCTOR (SANTA CLARA, CA)

*IF MACHINE WOUND, SLIGHTLY LARGER WIRE SIZES MAY BE USED.

Fig 3—This ultrasonic ranging system *features an ultrasonic transceiver (IC_1) and an electrostatic transducer (Y_1). Its sensing range is 4 in. to more than 30 ft.*

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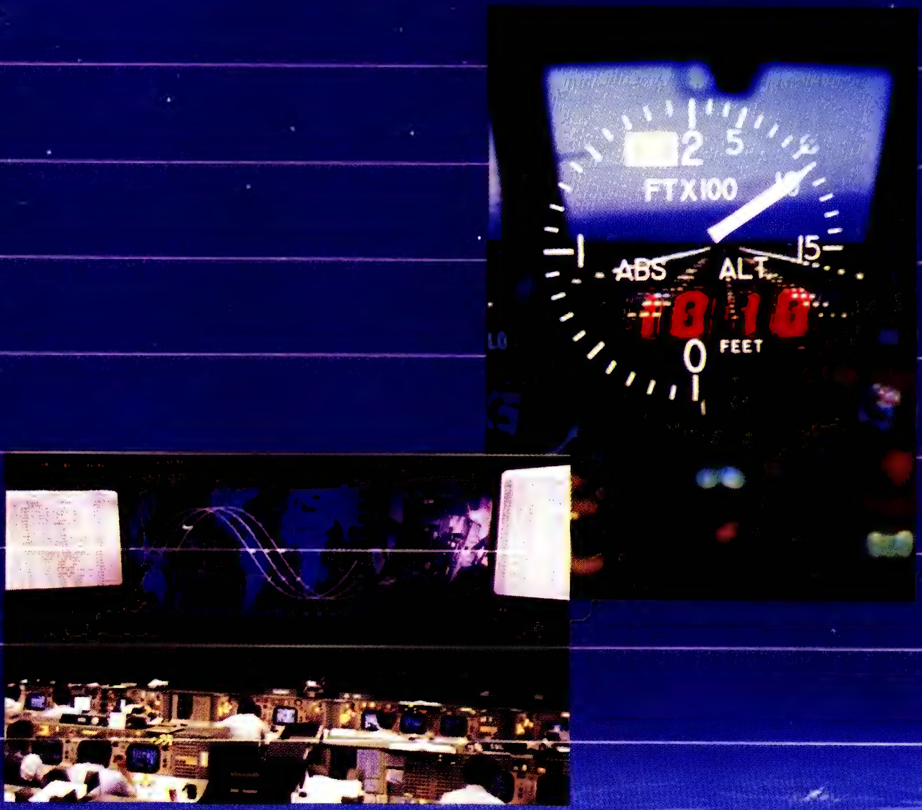

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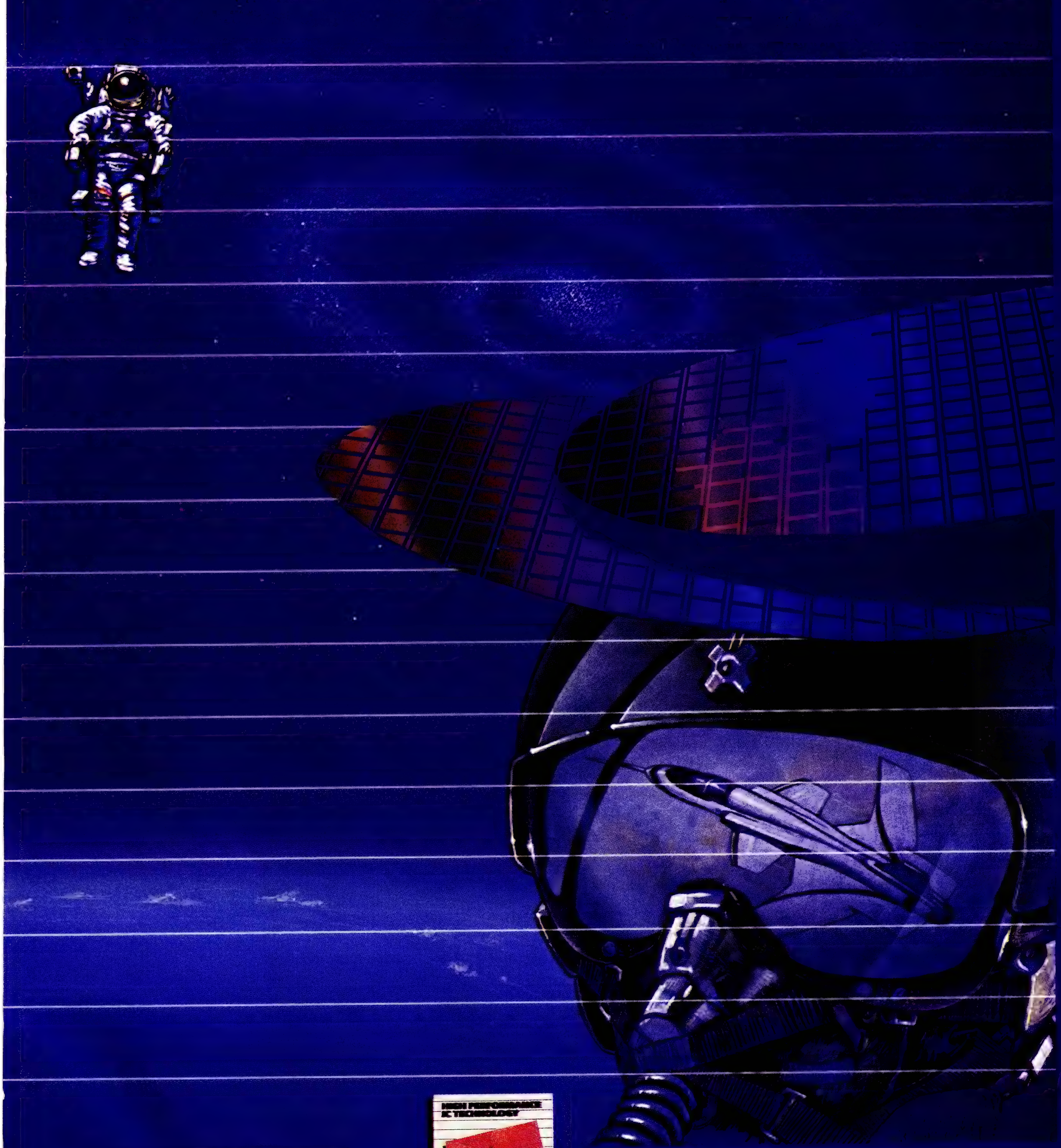

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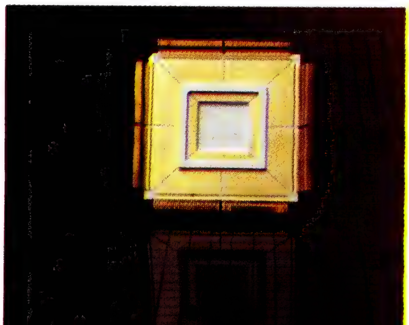

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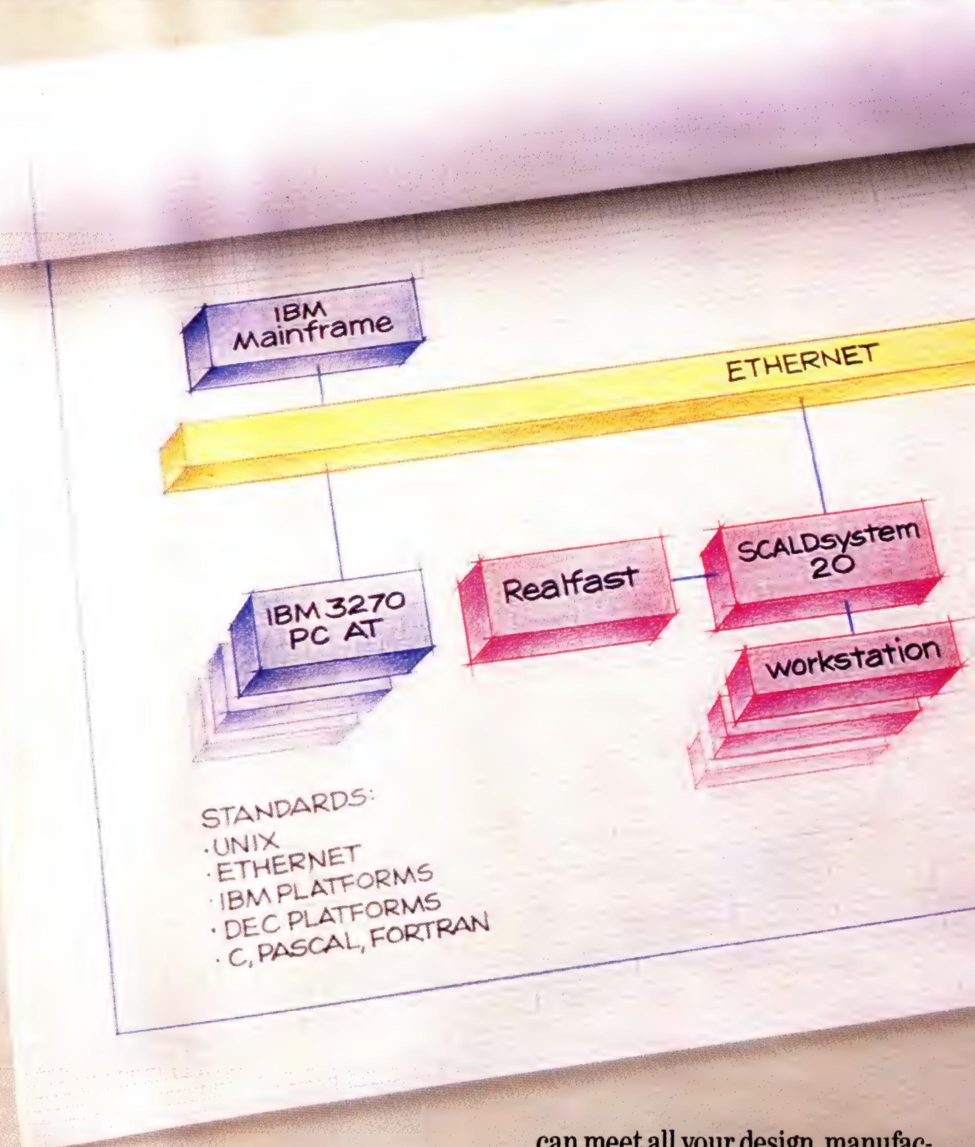

In 1980, a few people met to talk about starting a company with a new design methodology called Structured Computer-Aided Logic Design, or SCALD. Among them were the inventors of SCALD, Tom McWilliams and Curt Widdoes. SCALD's productivity was proven. In fact, it helped Tom and Curt develop the Navy's S-1 super computers in ten-percent of the time it would have taken using conventional design techniques.

SCALD would eventually become a CAE industry standard. But early on, Tom and Curt believed that if combined with other industry-wide standards it would be the ultimate solution for electronic engineering design. Everyone agreed. And a new company was born. A company called Valid.

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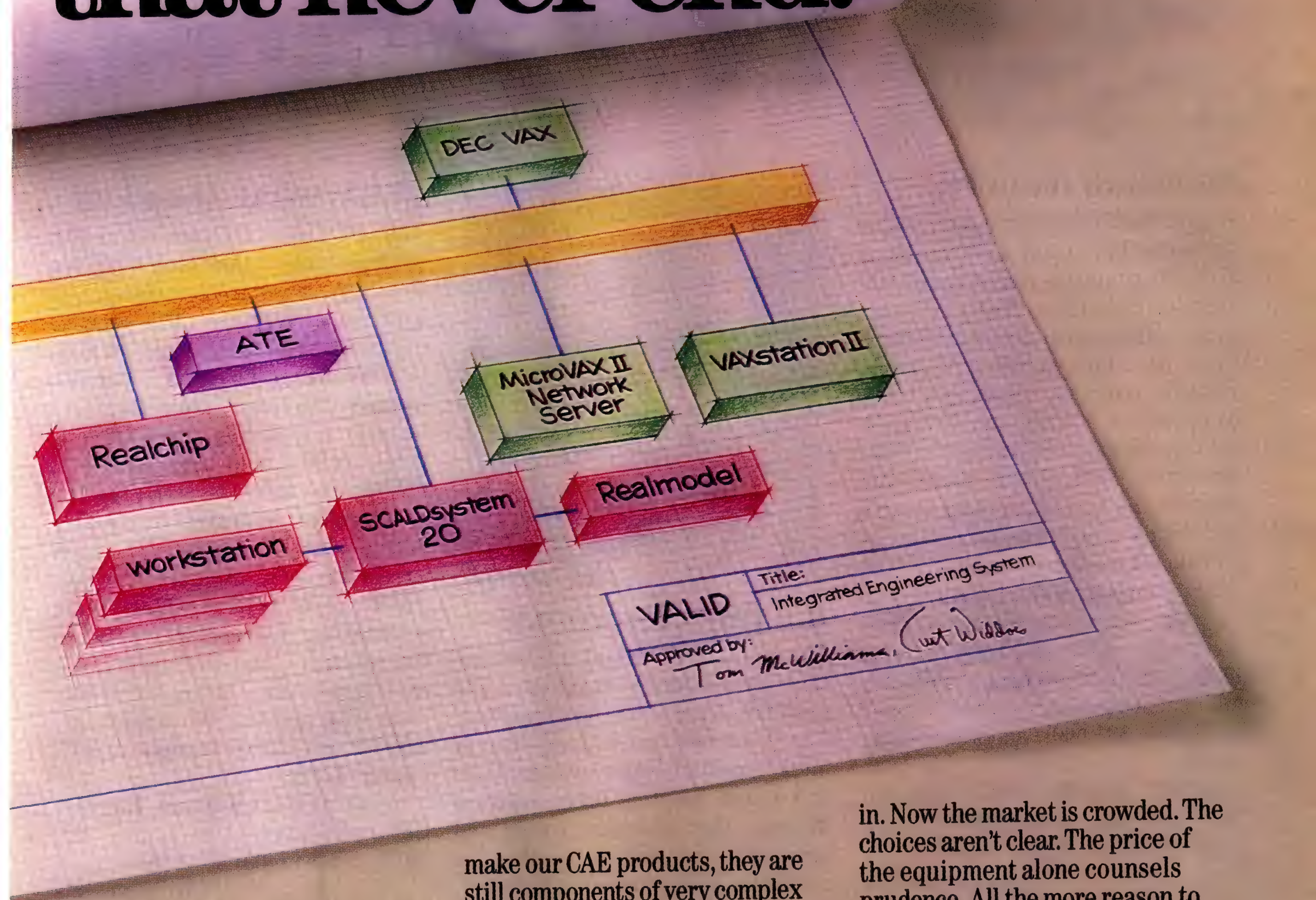

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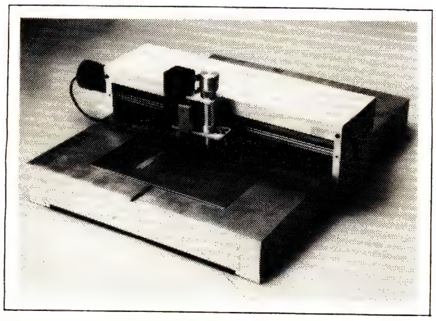

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SDA Systems, 2461 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 727-7811.

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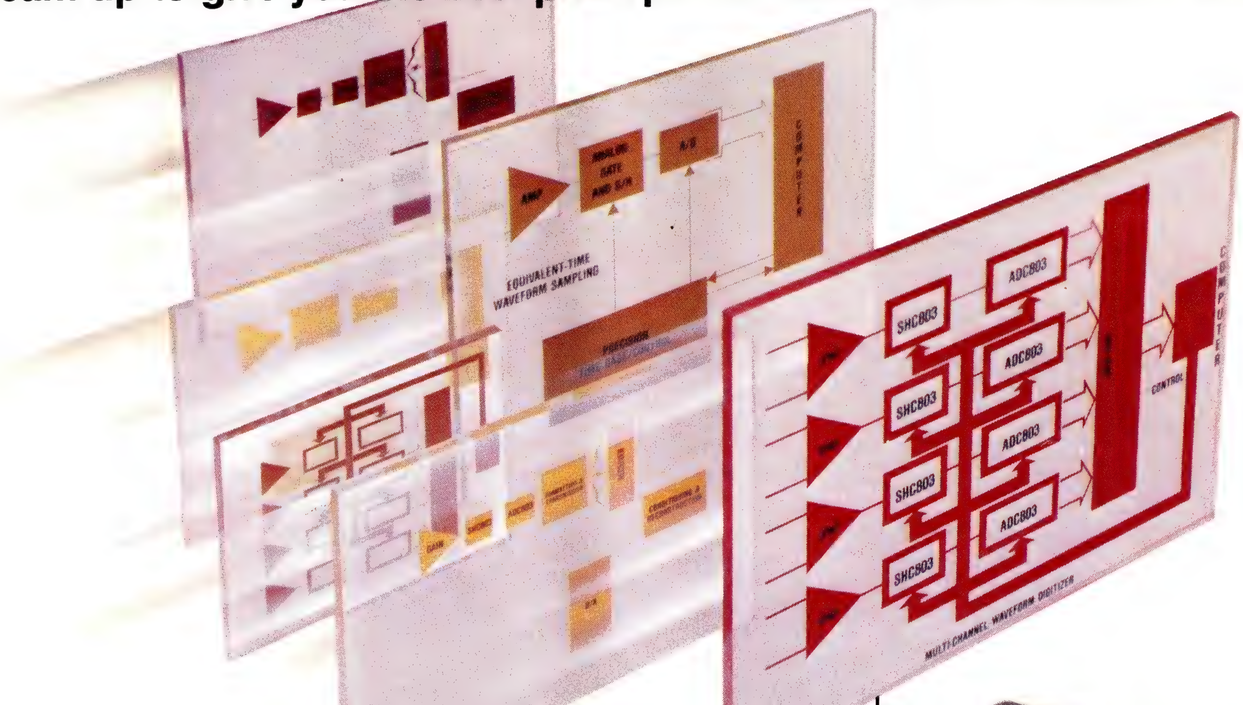

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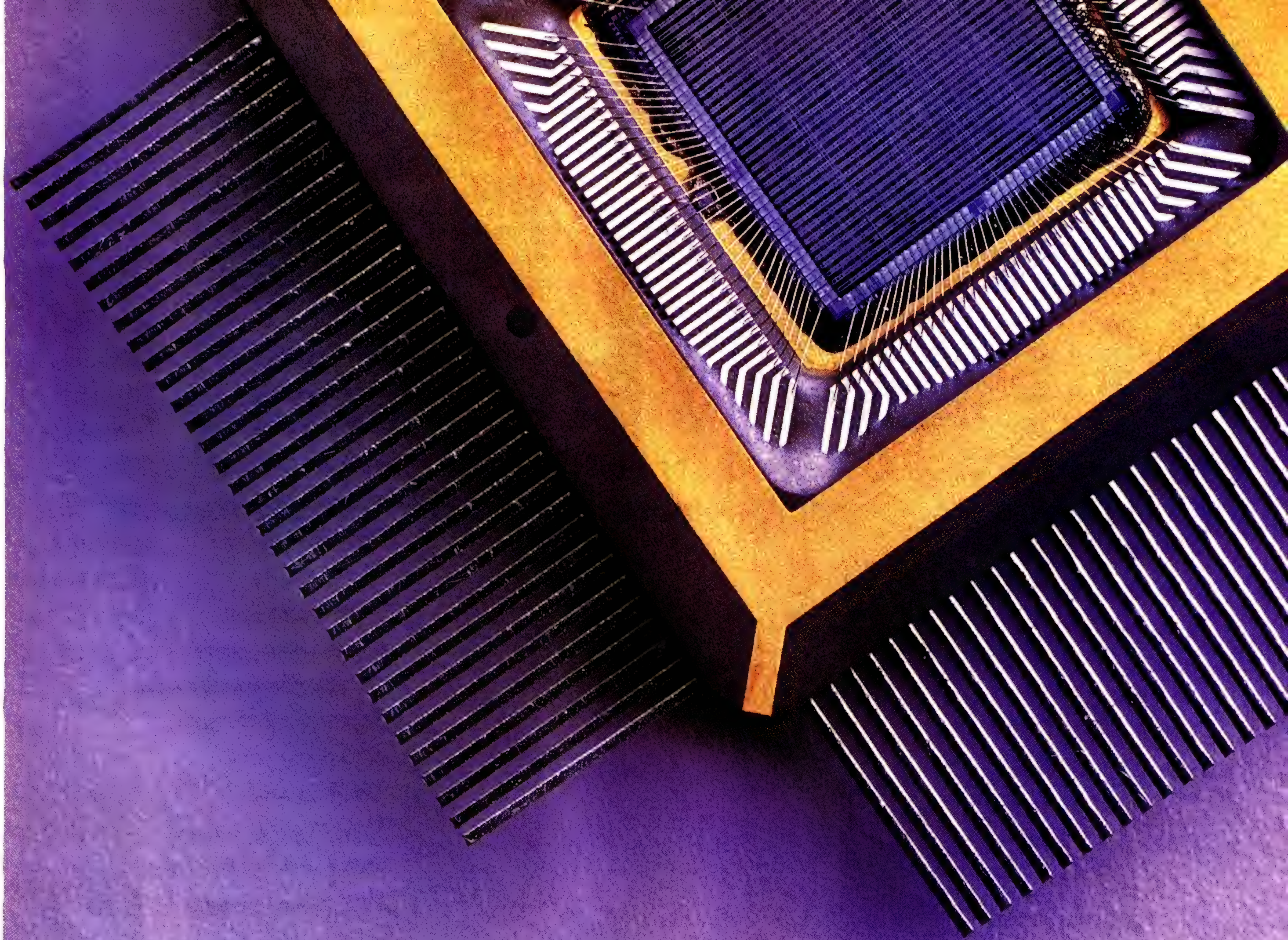

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Wire Graphics Inc, 95 Sherwood Ave, Farmingdale, NY 11735. Phone (516) 293-1525.

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MILITARY STATION

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Sun Microsystems Inc, 2550 Garcia Ave, Mountain View, CA 94043. Phone (415) 960-1300.

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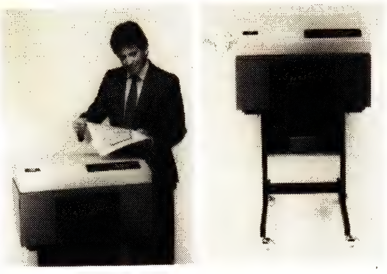

COLOR PLOTTER

The Spectrum electrostatic color plotter produces color or monochromatic plots on A-size (11×8½-in.) or B-size (11×17-in.) pages. The unit prints or plots on 11-in.-wide paper or polyester film at 2 ips; resolution is 200 points/sec. The plotter can produce color A-size pages in less than 60 sec and monochromatic

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drawings in 5 sec. It gives B-size color plots in less than 90 sec and monochromatic ones in 10 sec. An optional video interface, which includes a frame buffer, can generate hard copy from a color or monochromatic CRT. The unit includes an automatic media cutter for A- and B-size plots. Also included is a character generator that produces ASCII characters. In its monochromatic mode, the plotter emulates the company's V-80 printer/plotter, and prints 132 characters/line at a speed of 1000 lpm. Without additional software, the plotter produces seven line colors. When used with this company's Color Random software, which utilizes multidot pixels, the plotter can produce 256 predefined and 256 user-defined colors from a palette of more than 1000 colors. $11,950.

Versatec, 2710 Walsh Ave, Santa Clara, CA 95051. Phone (800) 538-6477; in CA, (800) 341-6060. TWX 910-338-0243.

Circle No 356

GRAPHICS STATIONS

The Iris Series 3000 family of real-time 3-D workstations consists of the 3010 terminal (20M-byte disk drive), the 3020 workstation (72M-byte disk drive), and the 3030 workstation (170M-byte disk drive). Each of these workstations features a 68020-based CPU, 8-MHz VLSI geometry engines, 2M bytes of memory (expandable to 16M bytes), eight bit planes of color (expandable to 32), and a 20-slot chassis. Also included are a 19-in. tilt-and-swivel color monitor, a keyboard, and an optical mouse. A floating-point processor board is optional. The 68020-based processor board provides a 32-bit data bus, which furnishes a 16-MHz clock speed. In addition, the workstations contain a set of specialized VLSI processors that generate 3-D graphics transformations at a rate of 86,300 transformations/sec. The workstations' Extent File System speeds up disk I/O without wasting any disk space. 3010, $39,900; 3020, $44,900; 3030, $54,900.

Silicon Graphics Inc, 2011 Stierlin Rd, Mountain View, CA 94043. Phone (415) 960-1980. TLX 350613.

Circle No 357

BURR-BROWN'S NEW INA105 . . .

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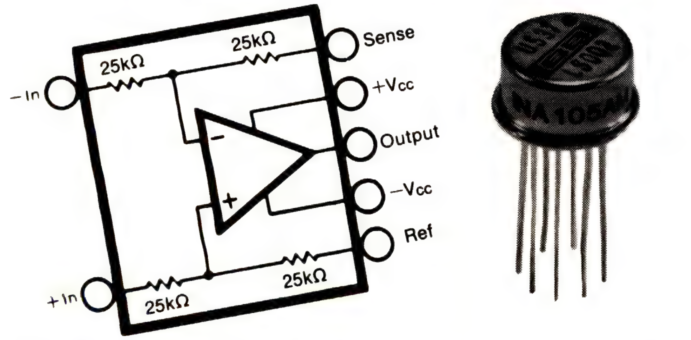

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For complete information on this new basic analog building block, ask your Burr-Brown sales representative or contact Burr-Brown, PO box 11400, Tucson, AZ 85734. (602) 746-1111.

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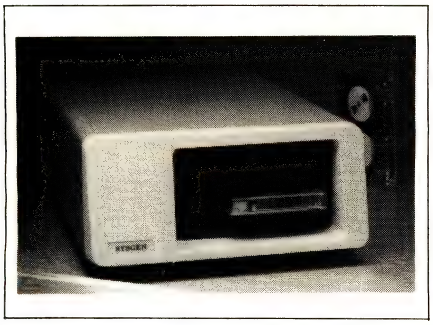
TERMINAL

This 80-column ASCII terminal, the Ant, features a 14-in. nonglare amber screen with a tilt-and-swivel base, a front-mounted power switch, and a side-mounted keyboard jack. The screen has a 24-line display with an additional status and message line. The terminal displays 7×9-dot-matrix characters within a 9×12-character cell. It also displays double-height, double-width characters. A 1.3-in.-high alphanumeric keyboard with 10 programmable function keys is standard. Also standard is a 16-symbol graphics set for developing bar graphs, charts, and forms. To reduce the risk of exposure to environmental hazards, the monitor cabinet houses all of the terminal's electronics. This terminal can emulate a Televideo TV910, Lear Siegler ADM3A and ADM5, and ADDS Viewpoint A2. $229.

CIE Terminals Inc, 2505 McCabe Way, Irvine, CA 92714. Phone (714) 660-1421.

Circle No 358



DISK/TAPE DRIVE

For use with IBM PC, PC/XT, PC/AT, and compatible computers, the Sysgen Plus subsystem combines a 70M-byte Winchester disk drive with a 60M-byte QIC tape backup. The Winchester has 70M bytes (formatted) of data storage, a 30-msec access time, and self-booting capability. The tape drive uses ¼-in. tape cartridges and provides automatic data backup for the Winchester. The tape offers both mirror-image and file-by-file back-up. You can also restore data from the tape to a disk other than the one originally backed up. The tape drive verifies data with a separate read head and corrects any errors during the recording process. $5995.

Sysgen Inc, 47853 Warm Springs Blvd, Fremont, CA 94539. Phone (415) 490-6770. TLX 4990843.

Circle No 359

READING THIS AD CAN SAVE YOU UP TO $10.00 PER WORD WHILE INTRODUCING YOU TO A TECHNICALLY SUPERIOR MULTIMETER

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PREMA now offers an internationally proven, 6-½ digit, 7-½ digit computational multimeter that sets new standards in performance—and saves you hundreds of dollars in the process. Here's a brief look at how the PREMA 6030 compares with a few of the more popular 6-½ digit units in terms of basic features and cost.

MFG Model	MATH PRG.	IEEE	VDC	VAC	7-1/2 DIGIT COMP.	INTERNAL CALIBRATION	2/4 WIRE	PUBLISHED 1-PC. PRICE
Prema 6030	✓	✓	✓	✓	✓	✓	✓	$3300
Solartron 7066	Limited	✓	✓	✓	✓	✓	✓	$3995
Datron 1061A	Limited	Option	✓	✓	No	✓	Option	$4490*
Fluke 8500	No	Option	✓	✓	No	Option	Option	$5740*

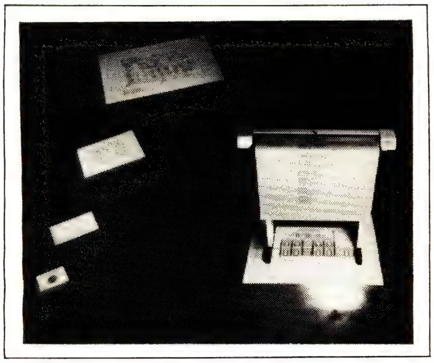
What's more, the PREMA 6030 features: a one year drift tolerance of 0.005% for direct voltage and resistance measurements, a maximum direct voltage range temperature coefficient of 0.0003%/°C, a resolution of 100 nV, integration times from 100 ms to 20 sec., continuous averaging, autozero, 100 dB suppression of power line frequency interference without a filter, a high impedance input of 10 GΩ up to ±20V, and an optional 20 channel scanner.

Price a PREMA. For more complete comparison and technical information on our 6-½ digit unit, give us a call today. Once you know the facts we think you'll agree that a PREMA 6030 leaves the competition behind. PREMA PRECISION ELECTRONICS, 6290 Sunset Blvd., Los Angeles, CA 90028. **Phone: (213) 463-2294.**

*Including options listed in comparison.

PREMA

CIRCLE NO 101

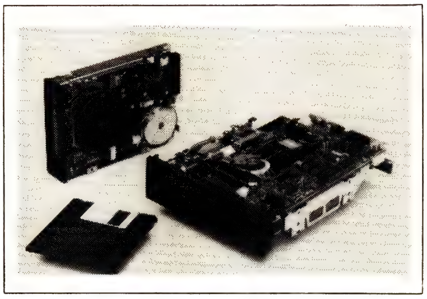


PLOTTER

You can generate 18 media sizes, ranging from 8½×11 in. to 36×48 in. on the DMP-56 plotter. Sizes include standard A through E drawings as well as metric A4 through A0 drawings. The plotter has a media-size adjustment mechanism and an automatic media-size sensor to facilitate changes in media dimensions via menu-driven commands. This servo-driven machine offers a resolution to 0.001 in. and a plotting speed of 17 ips max. It interfaces with any computer that has a serial RS-232C port. $5995.

Houston Instrument, 8500 Cameron Rd, Austin, TX 78753. Phone (800) 531-5205; in TX, (512) 835-0900.

Circle No 360



MICROFLOPPY DRIVE

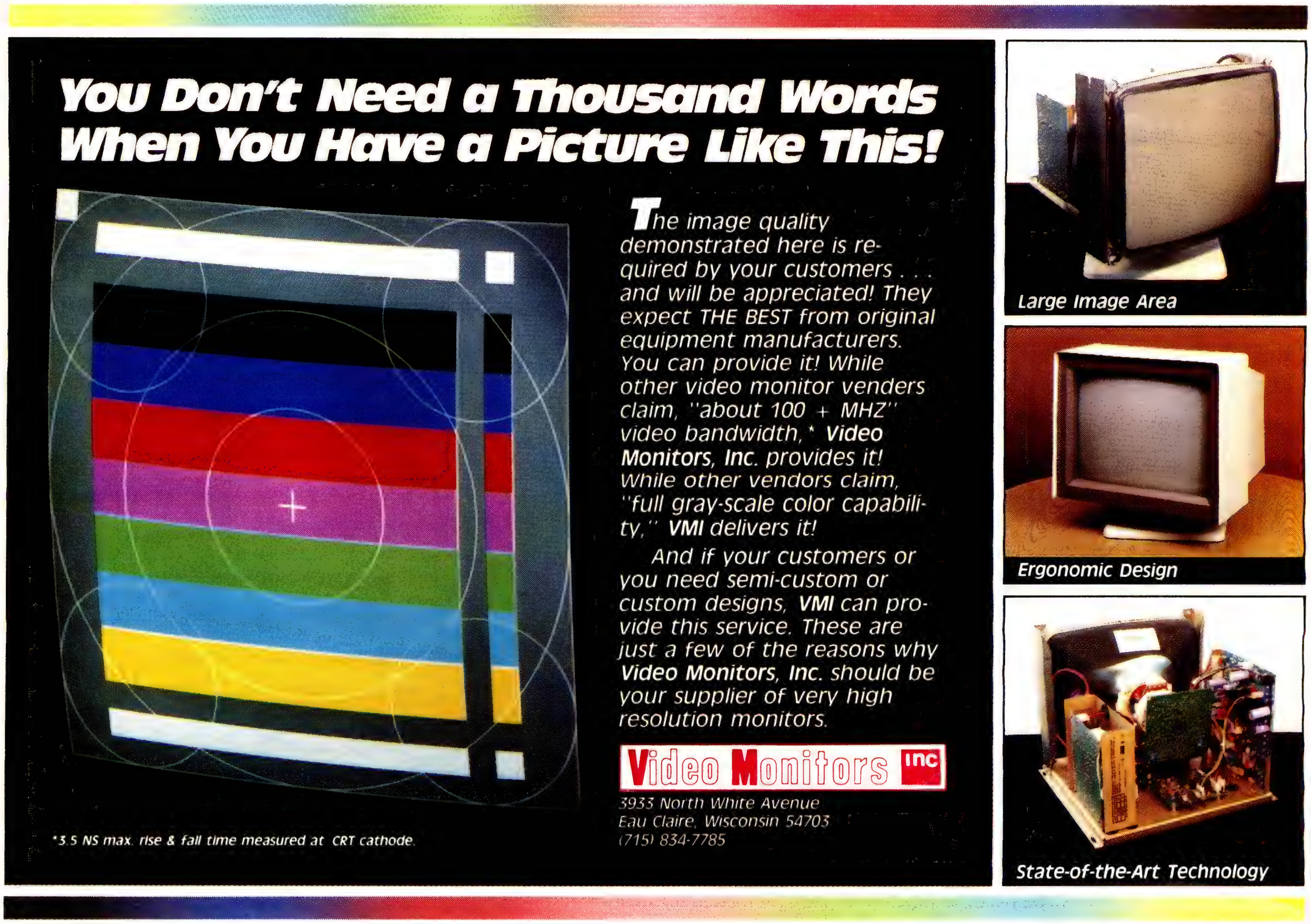
Able to place 1M byte of data on a 3½-in. microfloppy disk, the M2532A drive is only 1.26 in. tall and weighs only 1.52 lbs. Its average access time is 94 msec and the data-transfer rate is 250k bps (max). You can daisy-chain as many as four of these drives in a subsystem, or directly connect one to the controller of a standard 5¼-in. floppy-disk drive. Recording density in the drive's modified FM (MFM) mode reaches 8717 bpi. MTBF is greater than 10,000 power-on hours. The drive can withstand a shock as great as 10g while in operation. $112 (100).

Fujitsu America Inc, 3055 Orchard Dr, San Jose, CA 95134. Phone (408) 946-8777. TWX 910-338-2193.

Circle No 361

32-BIT COMPUTERS

Both the C1230 and C1260 superminicomputers provide communications and graphics features and can support as many as 128 users. The C1230 features a proprietary 32-bit processor, a floating-point coprocessor, a RISC-based architecture, and a Berkeley 4.2 Unix operating sys-



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Premiering April 10, 1986

tem. The C1260 gives you the option of using dual processors for faster program execution. Based on the Whetstone benchmark, the C1230 performs single-precision operations at 3.25 MIPS; the C1260 can run at 6.15 MIPS. Each air-cooled unit, enclosed in a 29×30×21-in. cabinet, plugs into a standard electrical outlet. C1230, from $75,000; C1260, from $110,000.

Celerity Computing, 9692 Via Excelencia, San Diego, CA 92126. Phone (619) 271-9940.

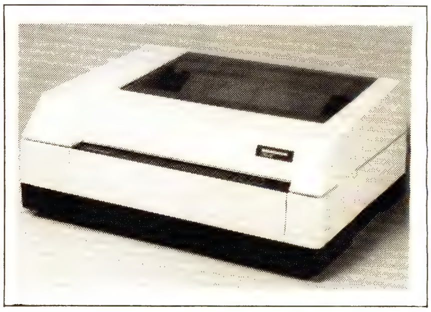
Circle No 362

COLOR DISPLAY

This IBM PC-compatible display, the LCS Color Graphtext System, gives you color graphics and text with a 640×400-pixel resolution. The system includes an LCS 1220 color-graphics display that incorporates a 12-in. liquid-crystal-shutter display. The liquid-crystal-shutter technology provides a picture that's sharper than a comparable RGB CRT picture. For graphics applications, you also receive an LCS E480 emulator card; it sends the display high-resolution signals while maintaining compatible operation with unmodified 200-line MS-DOS software. The system displays 16 colors in its emulation mode and lets you choose from three high-resolution text modes. One text mode displays a full-page 50-line screen using an 8×8-pixel character matrix. $1575.

Tektronix Inc, Box 500 M/S 46-556, Beaverton, OR 97077. Phone (503) 627-5000.

Circle No 363



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Producing draft-quality printing at 400 lpm, the MT540 line-matrix printer uses optional, interchangeable type-style cartridges for different print styles. In draft-quality

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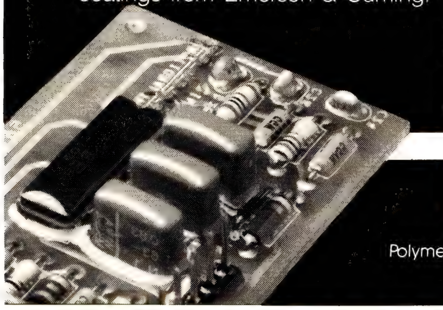

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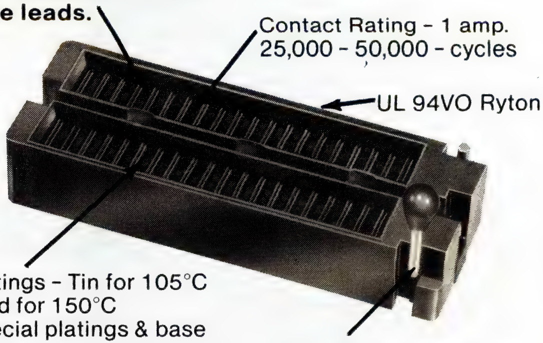

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CIRCLE NO 106

mode, the printer offers a 9×9 character matrix; in correspondence mode (about 100 lpm), it provides an 18×24 matrix. An adjustable tractor, combined with rear or bottom paper-feeding capabilities, can handle paper as wide as 16 in. and forms as thick as six pages. The printer can produce subscript, superscript, shadowed, and multiheight characters. Each ribbon cassette has a minimum lifetime of 20 million characters. $3495.

Mannesmann Tally Corp, 8301 S 180th St, Kent, WA 98032. Phone (206) 251-5500. TLX 320200.

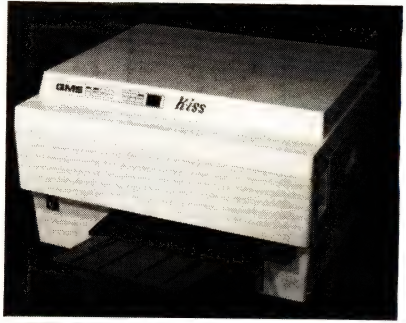
Circle No 364

PLOTTERS

The 5800 Series electrostatic plotters feature a palette of 1024 colors, 400-dots/in. resolution, and integrated vector-to-raster conversion. Suited for pc-board and IC design, these plotters also provide electronic registration, a proprietary method for ensuring 0.1% vertical and horizontal accuracy during multiple print passes. The Series comprises three models: The 5825 handles 24-in.-wide media; the 5835 handles 36-in.-wide media; and the 5845 handles 44-in.-wide media. Each model can generate plots as long as 500 ft. These plotters use specially treated dielectric media, including paper and film. The plotters place an electronic charge on the media and expose the media to as many as four liquid toners, each of which produces a different, permanent image on the media. Model 5825, $68,000; 5835, $91,000; 5845, $112,000.

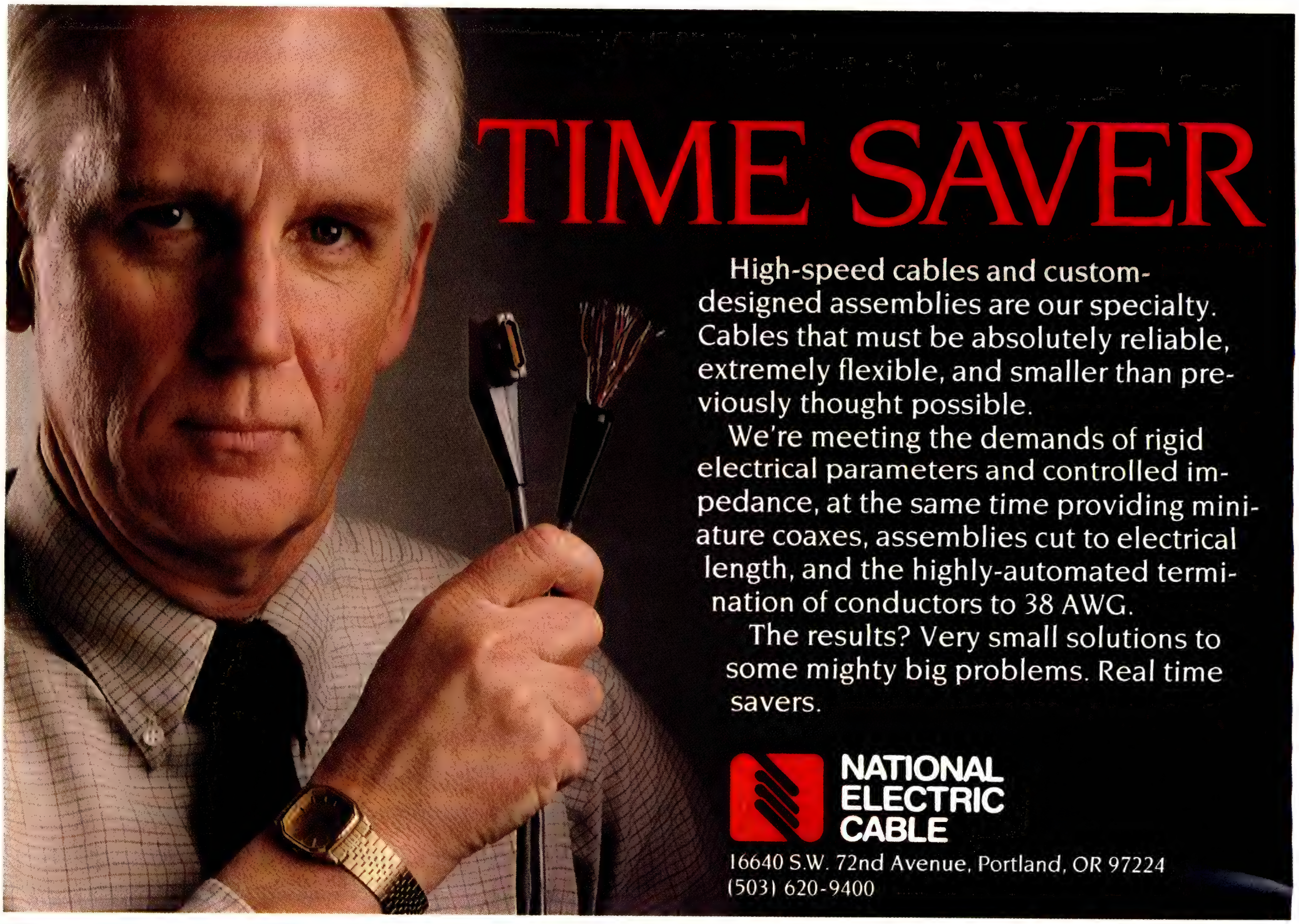
Calcomp, 2411 W La Palma Ave, Anaheim, CA 92801. Phone (714) 824-2142.

Circle No 365



LASER PRINTER

The Kiss laser printer offers a 6 page/minute print speed for $1995. The printer includes built-in printer



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System 8 handles all major 8-bit microprocessors with the same speed and features as System L. Then adds disassembly, including all exceptions and bus cycles, built-in non volatile memory, automatic test sequencing, powerful search and compare, eight saved set-ups and RS-232C communications. Its price: $4,685.

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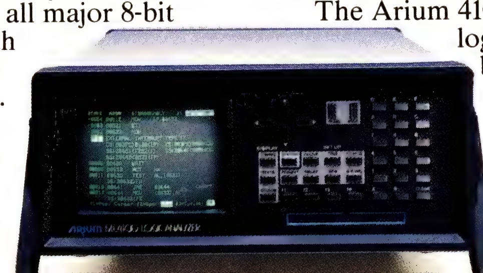

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emulations of Diablo, Epson, and Qume printers. Character resolution is 90,000 dots/in. This printer has 78k bytes of user-accessible memory, allowing you to intermix text and graphics on the same page. The printer also features 256k bytes of ROM, a 68000 µP, and a control panel. A Centronics parallel interface is standard; you can order an RS-232C interface. You also get nine resident fonts for as many as 40 print combinations.

QMS Inc, Box 81250, Mobile, AL 36689. Phone (205) 633-4300.

Circle No 366

ANSI/ASCII TERMINAL

The CIT 50+ is a 132-column terminal that supports both the ANSI and ASCII protocols. It offers emulation of a DEC VT100 ANSI terminal and a Wyse WY-50 ASCII terminal. You can use it as a 2-function terminal for applications involving multiple hosts. In addition to its 24-line×80- or 132-column display, the terminal has a status line and a label line. The 7×9-matrix characters have 2-dot descenders. The terminal has a 1.3-in.-high keyboard with 101 keys, including 32 programmable, nonvolatile function keys. The power switch is on the front of the cabinet. $599.

CIE Terminals Inc, 2505 McCabe Way, Irvine, CA 92714. Phone (800) 624-2516; in CA, (714) 660-1421.

Circle No 367

MODEM

Providing asynchronous data communication at 300, 1200, and 2400 bps or synchronous communication at 1200 and 2400 bps, the 224A/D modem operates with both terminals and microcomputers. The modem uses V.22 and V.22 bis modulation to permit full-duplex operation over the public switched telephone network. At 1200 and 300 bps, the unit functions as a Bell 212A or 103 modem. Its capabilities include tone or pulse dialing, automatic answering, blind dialing, and built-in diagnostic testing. A nonvolatile battery-backed memory stores as many as 10 telephone numbers or log-on sequences. $645.

Universal Data Systems, 5000 Bradford Dr, Huntsville, AL 35805. Phone (205) 837-8100. TWX 810-726-2100.

Circle No 368

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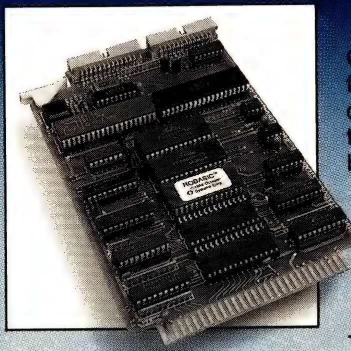
for real-time STD Bus control.



Octagon's NEW 880B Multifunction CPU is a system designer's dream card. With the built-in software and hardware features, the 880B can be a stand-alone control system. Just connect a terminal, turn on the power and you are ready to program.

The resident ROBASIC™ software is more than BASIC. This fast, compiled language lets you write your programs right on the card. The ROMmable code executes automatically on power up. 73 of the 140 commands talk to your STD Bus peripheral cards. Supports 16 concurrent tasks which can be called by name. Powerful, yet easy.

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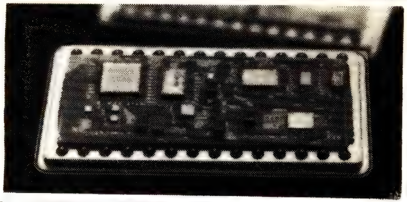
- 5 counter/timers
- STD Bus compatible
- **$595**

For more information call **303-426-8540.**

OCTAGON SYSTEMS CORPORATION
6501 W. 91st • Westminster, Colorado 80030

CIRCLE NO 105



DATA SYSTEMS

The 12-bit AD369 data-acquisition systems combine a programmable-gain instrumentation amplifier, a track-and-hold amplifier, and a 12-bit A/D converter in a 28-pin metal package. The units feature a system throughput of 50 kHz at software-programmable gains of 1, 10, and 100, and throughput of 20 kHz at a gain of 500. They can operate in a bipolar or unipolar mode, with a 10V span at a gain of 1. Two versions, the AM and the BM, guarantee maximum nonlinearity of ¾ LSB and ½ LSB, respectively. Monotonicity is guaranteed over −25 to +85°C for both versions. The A/D converter uses the successive-approximation technique to achieve 0.012% maximum nonlinearity and a conversion time of 15 μsec max. Track-and-hold acquisition time is 3 μsec max. Typical power consumption is 775 mW. AM version, $107; BM version, $124 (100).

Analog Devices Inc, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565.

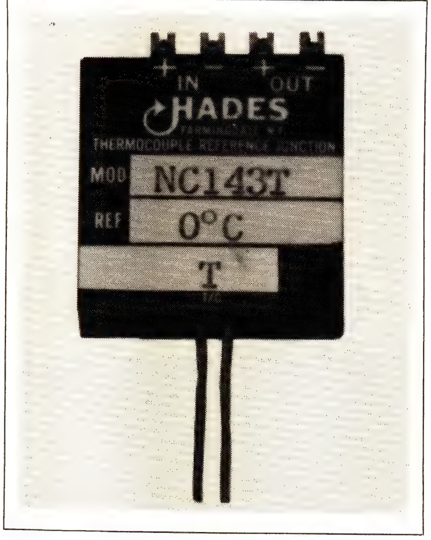
Circle No 369

REFERENCE JUNCTION

You can order the Model NC143 with any reference-temperature setting within its operating range of −65 to +125°C (operation to 200°C is also available). The junction is available for all thermocouple materials and power sources. This miniature full-bridge reference junction with two mounting holes and either solder terminals or leads eliminates the need for ice or electromechanical temperature-simulation devices. The unit is externally powered by 1, 1.35, 5, or 10V dc, as required. Power consumption can be as low as 100 μW. Temperature stability is >±0.25°C at any stabilized ambient temperature between −54 and +100°C. Output impedance is <250Ω standard, with other output impedances available upon request. The module is designed to meet or exceed MIL-E-5400. $53.10 (100).

Hades Manufacturing Corp, 151 Verdi St, Farmingdale, NY 11735. Phone (516) 249-4244.

Circle No 370

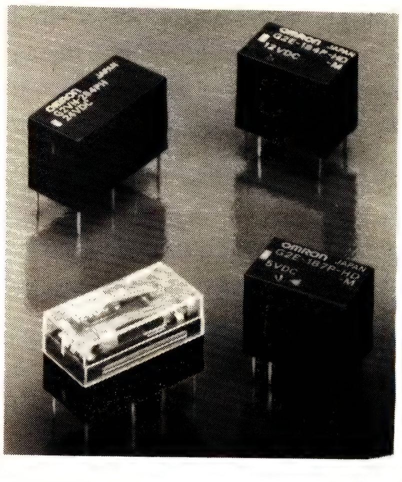


PANEL METERS

The CPM500 Series panel meters combine analog display with digital electronics for high visibility and accuracy. Because the output intensities of the LED segments are matched, the 50 bar-graph segments have uniform color and visibility; the matching also creates a continuous bar that lets the user see the meter from a distance or in dim light. Input signals are displayed on the circular bar graph with an accuracy to 0.5% or 0.1% with the optional 3- or 4½-digit display. The meters have a full-scale response time of 2.5 msec for dc or digital inputs and 300 msec for ac inputs. The CPM500 features a dc-signal input for analog representation of process conditions. The CPM510 accepts 7-bit binary signals. The CPM520 will respond to ac frequencies from .40 to 1000 Hz. The CPM542 features simultaneous display of process variables and set points on one analog scale. The meters are designed to operate in harsh environments. CPM500, $310. Delivery, six weeks ARO.

Bowmar/Ali Inc, Box 10, Acton, MA 01720. Phone (800) 343-5202; in MA, (617) 263-8365.

Circle No 371



RELAYS

G2E-M spdt relays are compatible with automatic machine-insertion equipment and automatic soldering systems. Units are available in either single- or bifurcated-crossbar types in general-purpose or high-sensitivity models. Rated coil voltages range from 1.5 to 24V dc. Load capability equals 0.5A at 110V ac and 0.3A at 24V dc for inductive loads. The general-purpose relays draw about 450 mW, and the high-sensitivity units consume approximately 200 mW. Operating times

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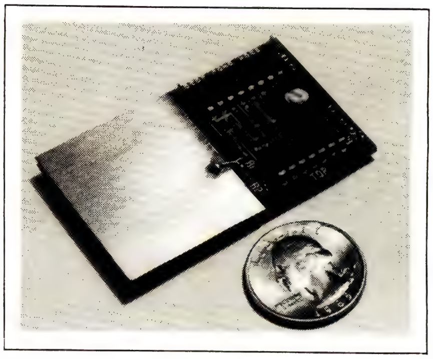
are 5 and 7 msec, respectively. Service life is rated at 10 million operations in the operating range of −25 to +60°C. $2.10. Delivery, six weeks ARO.

Omron Electronics Inc, 1 E Commerce Dr, Schaumburg, IL 60195. Phone (312) 843-7900. TWX 910-291-0426.

Circle No 372

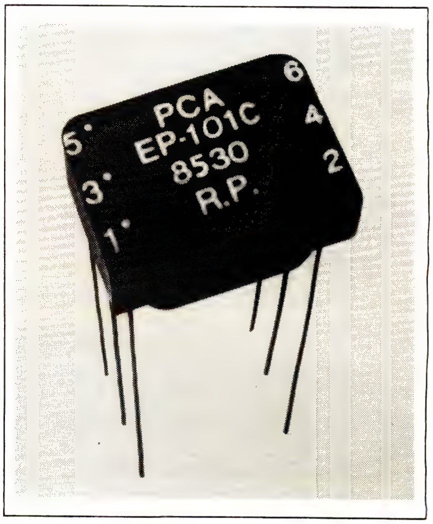
PIEZOELECTRIC FANS



Series LP-1200 low-profile dc-operated fans are designed for applications requiring concentrated air flow or cooling in severe environments. Each fan provides, on demand, a planar airjet that has an average velocity greater than 250 feet/minute in an airstream of 1.5×1.5×0.25 in. Measuring 2.7×1.5×0.25 in. and weighing 0.6 oz, the 12V model delivers 0.8 cfm continuously and consumes 50 mW. A 24V model delivers 1.5 cfm and uses less than 200 mW. The fans are fully wave solderable. According to the manufacturer, RFI and EMI are negligible and start-up is virtually instantaneous without the power surges usually encountered with conventional fans. $250.

Piezo Electric Products Inc, 240 N Washington Blvd, Sarasota, FL 33577. Phone (813) 366-1458.

Circle No 373



PULSE TRANSFORMERS

The EP101, EP111, EP211, EP311, and EP331 Series pulse transformers have turns ratios of 1:1, 1.1:1, 2.1:1, 3.1:1 and 3.1:1, ±5%, respectively. Each transformer is available with a broad range of characteristics. For example, the 2-winding, center-tapped EP101C-602 has a primary inductance of 6000 µH, 1.26-µH leakage inductance, 5Ω primary dc resistance,

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CIRCLE NO 114

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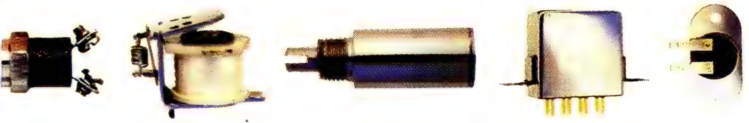

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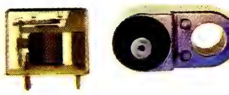


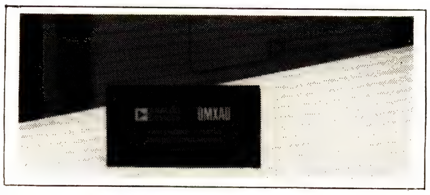
78-pF interwinding capacitance, 9-pF effective distributed capacitance to ground, and a 30 V-μsec voltage-time constant. Operating range is −10 to +125°C. $2.50 (1000) for the EP101C-602. Delivery, stock to six weeks ARO.

PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761.

Circle No 374

OUTPUT MODULE

The QMXAO module reduces the cost of using the manufacturer's μMAC-5000 system for small-scale control applications by providing 2 to 4 channels of analog output directly from the 5000 system without adding expansion boards. The module plugs directly into a socket on the 5000's master board. It provides 12-bit D/A resolution and voltage (0 to 10 or −10 to +10V) and current (0 to 20 or 4 to 20 mA) outputs,



which are simultaneous. Each channel has 1000V isolation. In the voltage mode, the module provides enough current to allow it to serve as a programmable sensor-excitation source. $295.

Analog Devices Inc, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-3359.

Circle No 375

TYPE-D CONNECTORS

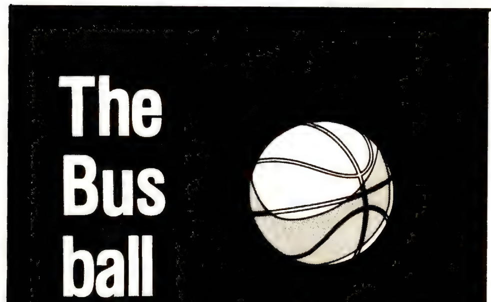
These male and female insulation-displacement connectors directly accept 0.05-in. pitch cable and include feedthrough covers to permit chain interconnections. The type-D subminiature connectors accommodate 30-AWG solid and 28- or 26-AWG stranded conductors. They have metal shell protection and shielding at the mating interfaces and are available with screw locks, check nuts, slide-lock retainers, or spring-lock retainers. In addition, you can purchase the connectors with integral 4/40 nut mounting hardware and full strain-relief caps. Connector moldings are glass-filled polyester with a UL flammability rating of 94V-0. Contacts are copper-based alloy, and contact plating is 50-μin. nickel with 30-μin. gold at the plug area. $6.85 for a 50-position connector (OEM qty).

Carrot Components Corp, 750 W Ventura Blvd, Camarillo, CA 93010. Phone (805) 484-0540. TWX 910-336-1237.

Circle No 376

DATA SYSTEM

This hybrid data-acquisition subsystem, Model AH9612, contains a 16-



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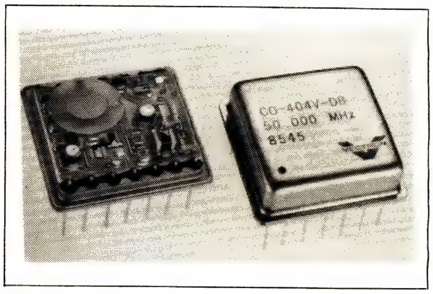
CIRCLE NO 116

channel multiplexer, a programmable-gain instrumentation amplifier, a self-contained S/H amplifier, and a 12-bit, 25-μsec A/D converter in a 64-pin DIP. The amplifier offers programmed gains of 1 to 1000, and the A/D converter is compatible with the 12-bit 574 A/D converter. A free-running mode allows automatic sequencing and stand-alone operation. The adjustable 10V reference provides 10 mA for driving external circuitry. This subsystem is available in ±½- and ±1-LSB differential-linearity grades, both with 86-dB CMMR, 80-dB multiplexer crosstalk, and 80-dB S/H feedthrough. Both grades dissipate 1.6W max. ±½-LSB grade, $142; ±1-LSB grade, $110 (100).

Analogic Corp, 8 Centennial Dr, Centennial Industrial Park, Peabody, MA 01961. Phone (617) 246-0300. TWX 710-348-0425.

Circle No 377



DIP OSCILLATORS

The CO-404V Series hybrid voltage-controlled crystal oscillators are designed specifically for phase-locking applications. They provide TTL output at specified center frequencies from 25 to 70 MHz. Deviation for 0 to 5V control signals ranges from ±30 to ±100 ppm. This deviation allows you to lock onto the specified center frequency over the operating range (0 to 50°C or −55 to +85°C) for 10 to 20 years without adjustment. These 0.2-in.-high, double-DIP, resistance-welded oscillators are rated at 10^{-8} atm/cc in fine-leak testing per MIL-STD-883. The 3-point crystal mount results in sine and random vibration levels exceeding 20g to the 2-kHz point. They conform to MIL-O-55310 and are available screened to level B. From $130 (25). Delivery, 10 weeks ARO.

Vectron Laboratories Inc, 166 Glover Ave, Norwalk, CT 06850. Phone (203) 853-4433. TWX 710-468-3796.

Circle No 378

SIP NETWORKS

The MRN SIP resistor networks feature a ¼W power rating and provide pullup, pulldown, and voltage-dividing functions. Available in values of 10Ω to 2.2 MΩ, the networks spec a 100-ppm TC resistance with a 2% tolerance. They are rated at 150V dc over −55 to +125°C. Five-through 8-pin SIP networks come in

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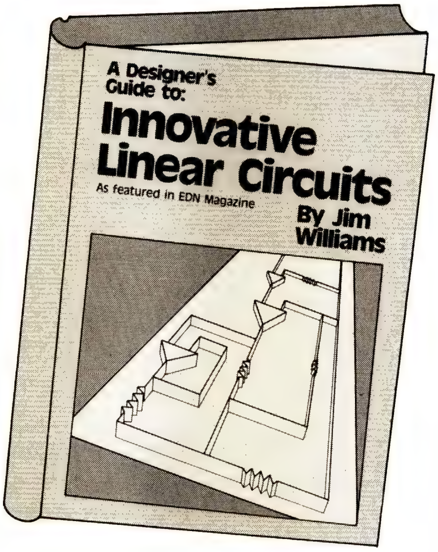

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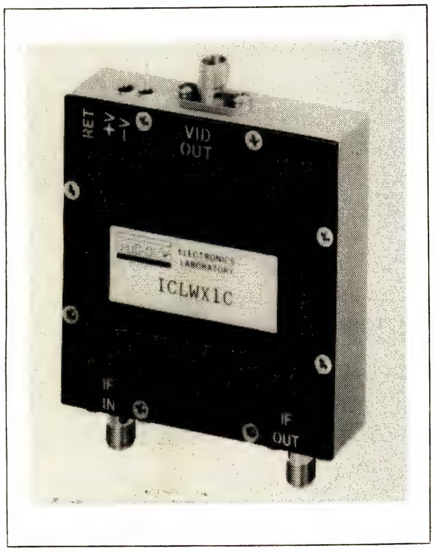
1500-piece packages; 9- through 12-pin SIP networks come in 1000-piece packages. $0.012/pin (10,000). Delivery, eight to 10 weeks ARO.

Kyocera International Inc, Electronic Components Group, 11425 Sorrento Valley Rd, San Diego, CA 92138. Phone (619) 454-1800.

Circle No 379



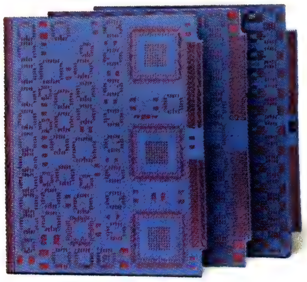
LOG AMP

The ICLWX1C is designed to meet environmental standards as defined in MIL-E-5400 and MIL-E-16400 and operates over −54 to +71°C. Typical specs include a 1-GHz frequency, 700-MHz bandwidth, dynamic input range of −60 to 0 dBm, and ±1-dB linearity. The amplifier will deliver 750 mV into a 50Ω load. Transfer slope equals 12 mV/dB (nominal), and input impedance is 50Ω. $3750. Delivery, 150 days ARO.

RHG Electronics Laboratory Inc, 161 E Industry Ct, Deer Park, NY 11729. Phone (516) 242-1100. TWX 510-227-6083.

Circle No 380

"Having a reliable source of ceramic PWBs has been the problem with using leadless chip carriers. Until now."



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CIRCLE NO 118

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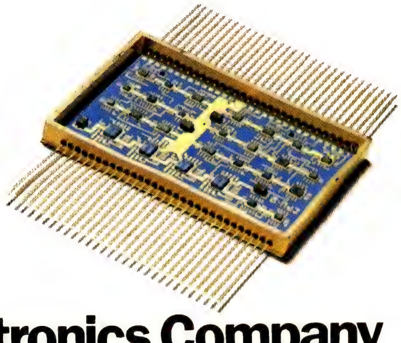

Boeing Electronics Company
Reliability By Design

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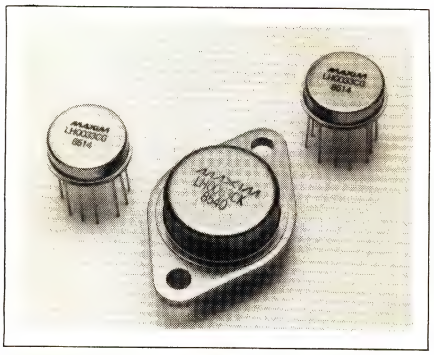


BUFFER AMPLIFIERS

The LH0033 and LH0063 unity-gain buffer amplifiers provide high-current drive at frequencies from 0 to 300 and 100 MHz, and at slew rates of 1500 and 6000V/μsec, respectively. The buffers can drive loads as low as 50Ω and can provide as much as 600 mA (LH0063) of output drive. Both devices are JFET-input followers that exhibit very low input-bias current: 100 pA max (LH0033) and 500 pA max (LH0063). You can use these amplifiers as high-speed line drivers, as nuclear-instrumentation amplifiers, and as operational-amplifier isolation buffers for driving inductive loads. The ICs can also serve as high-impedance buffers for high-speed A/D converters and comparators. In a hermetically sealed TO-8 package, LH0033, $17.34; LH0063 $23.80 (100).

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086. Phone (408) 737-7600.

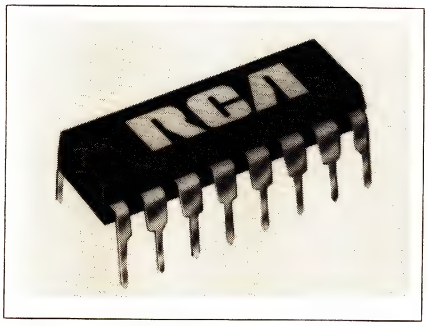
Circle No 381

POWER MOSFETs

These 10 power MOSFETs now meet JAN qualifications. The devices include even part numbers 2N6756 through 2N6766 and 2N6796 through 2N6802 (JAN, JANTX, and JANTXV levels). Breakdown-voltage ratings span 100 to 500V; continuous-current capabilities are 1.5 to 38A. The MOSFETs suit power-conversion and motor-control applications in high-reliability or harsh military environments, for example, switching power supplies, dc/dc converters, and power drivers. In TO-3 and -39 packages, $9.73 to $74.20 (100).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 382



FULL-ADDER IC

The CD4560B full-adder IC performs sums in the natural BCD (NBCD) format. The device accepts two 4-bit BCD input values, plus a carry-in value, and produces a 4-bit sum output and a carry-out bit. Output values are valid only when the sum of the inputs is 19 or less. Although invalid outputs result when sums are greater than 19, they are consistent and reproducible. It meets JEDEC Standard 13B and comes in three packaging styles, as well as in chip form, for use in the military temperature range. In addition, it's available in a 16-lead plastic DIP for the −40 to +85°C range. The CMOS-processed IC has a maximum input current of 1 μA at a supply voltage of 18V over the full temperature range. CD4560B in plastic DIP, $3.14 (100).

RCA, Solid State Div, Box 2900, Somerville, NJ 08876. Phone (201) 685-6104.

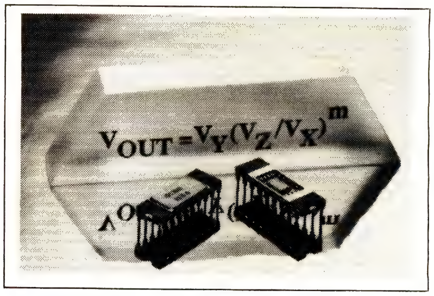
INQUIRE DIRECT

13-BIT CONVERTER

The TEA1017 13-bit serial-to-parallel converter has 13 push-pull outputs, each capable of providing 80-mA max drive current in both directions. Each output has an integral clamping diode, suiting the IC for directly driving inductive loads. You can connect two outputs in parallel. An internal heat spreader allows the IC to safely dissipate as much as 1.4W between the ambient temperatures of −20 and +80°C. Supply-voltage range is 5 to 18V. In an 18-lead plastic DIP, it costs $2.02 (100).

Signetics Corp, Box 3409, Sunnyvale, CA 94088. Phone (408) 991-5396.

Circle No 384



COMPUTATION IC

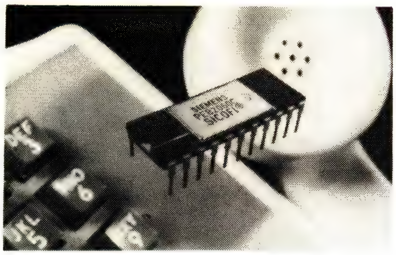
Claimed by its manufacturer to be the first analog computational IC, the AD538 has the transfer function

$$V_{OUT}=V_Y(V_Z/V_X)^m;$$

it can thus provide simultaneous multiplication and division, powers, and roots of analog currents or voltages. The IC's 100-μV input offset voltage allows division of analog signals over a 1000:1 dynamic range. The device incorporates log-ratio and antilog circuits, a current-to-voltage output stage, and a 2V/10V reference. The unit subtracts logs to perform division and adds logs for multiplication. You can use the IC, with no external components, to perform 1-quadrant multiplication and division. A few external components allow the device to provide 2-quadrant products and quotients. Operating from ±4 to ±18V supplies, the AD538 consumes 250 mW max. Enclosed in an 18-pin ceramic DIP, the unit is available for −25 to +85°C and −55 to +125°C ranges. $17.50 (100).

Analog Devices Inc, Literature Ctr, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565.

Circle No 385

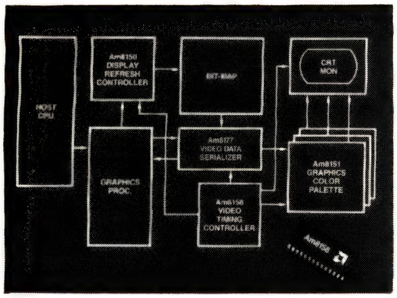


CODEC/FILTER

The PEB 2060 is a PCM codec and transmit/receive filter that conforms to CCITT and AT&T international standards. Thanks to its digital filtering, you can use software to perform impedance matching, trans-hybrid balancing, gain control, and frequency-response corrections. Other features include A/D and D/A conversion, PCM coding/decoding according to the A law and μ law; A/D loop-back testing; and programmable interface to peripherals. The device operates from ±5V. It accommodates 3-party teleconferencing and requires no external components, trimming, or adjustments. In a 22-pin DIP, $14 (10,000).

Siemens Components Inc, 186 Wood Ave S, Iselin, NJ 08830. Phone (201) 321-4520.

Circle No 386


HOST CPU
Am8150 DISPLAY REFRESH CONTROLLER
BIT-MAP
CRT MON
GRAPHICS PROC.
Am8177 VIDEO DATA SERIALIZER
Am8158 VIDEO TIMING CONTROLLER
Am8151 GRAPHICS COLOR PALETTE
Am8158

VIDEO IC

The Am8158 is a programmable video-timing controller for high-resolution bit-mapped graphics systems of 1k×1k pixels or more. The IC supports a 125M-dots/sec clock rate and has nine programmable registers that contain the timing parameters for generating control signals. It generates the necessary synchroni-

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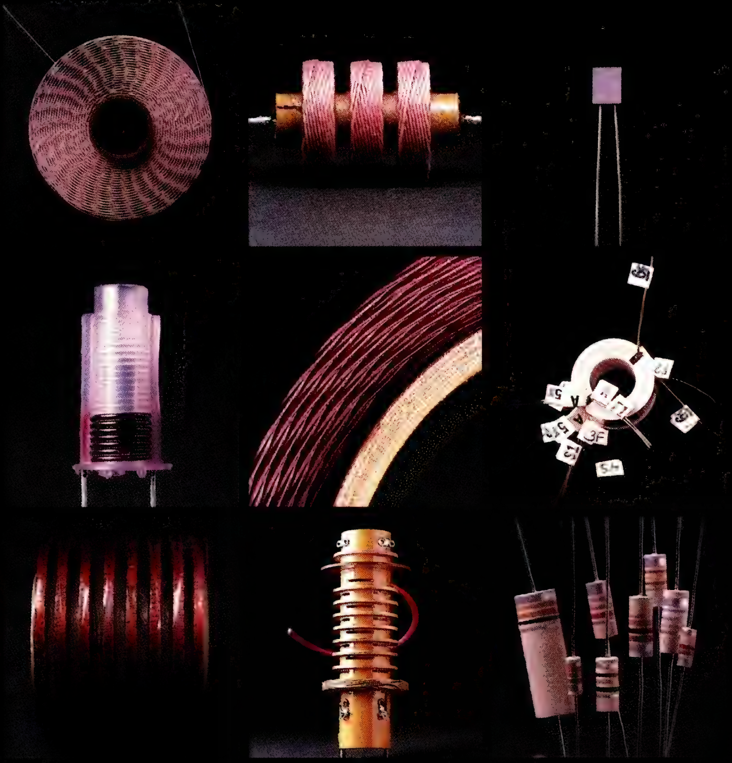

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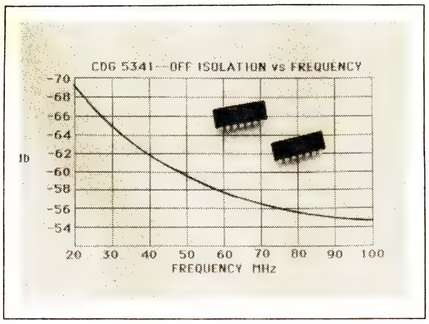
B
INDUSTR

CIRCLE NO 162

zation signals for the CRT display and other devices—for example, an Am8150 display refresh controller and an Am8177 video shift register —in a graphics system. You can program the number of pixels per memory access, memory accesses per scan line, and scan lines per frame, as well as the pulse widths of the synchronization signals. In a 28-pin ceramic DIP, $38.60 (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 982-7448.

Circle No 387



ANALOG SWITCH

The CDG5341 2-channel, high-frequency analog switch specs −70-dB off-state isolation at 20 MHz. The IC incorporates CMOS logic-control and level-shifting circuitry and DMOS analog switches. The DMOS portion uses a T configuration, a switch topology that provides high isolation. For example, at 100 MHz, isolation drops only from −70 to −55 dB. In the T connection, two series-connected switches provide the analog signal path; a third switch is connected between the first two switches and ground. The IC's logic drives the third switch out of phase with the other two, such that in the off-state mode, a low-impedance path to ground shunts any undesired signal away from the load. The logic circuitry accepts inputs from 5V CMOS logic and transforms the inputs to the voltage levels necessary to control analog signals as great as 20V p-p. Housed in a 14-pin plastic DIP, the CDG5341 operates from ±15V supplies and switches in less than 150 nsec. $3.76 (100).

Topaz Semiconductor, 1971 Capitol Ave, San Jose, CA 95132. Phone (408) 942-9100.

Circle No 388

DIAGNOSTIC PROMs

The Am27S65A/75A/85A diagnostic PROMs offer 40% performance improvement over competitive devices, according to the manufacturer. System cycle times are 33, 37, and 39 nsec, respectively, and the PROMs' on-chip serial shadow registers provide the capability to detect and locate hardware-related system problems. The Am27S65A (1k×4), Am27S75A (2k×4), and Am27S85A (4k×4) all incorporate two 4-bit registers. You can use one, the shadow register, to control and

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CIRCLE NO 125

observe the output data register for testing purposes. This diagnostic feature facilitates troubleshooting during board design, prototype development, and field repairs. In 24-pin ceramic DIPs, the Am27S65A/75A/85A cost $18.50, $29, and $46 (100), respectively. The devices are also available in plastic DIPs and LCCs.

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 982-7445.

Circle No 389

D/A CONVERTER

The Bt450 monolithic triple 4-bit D/A converter operates at speeds as high as 70 MHz. The device integrates three 4-bit video DACs, a 16×12-bit dual-port color-look-up table, a 3×12-bit dual-port overlay palette, and a microprocessor interface. It supports as many as 19 simultaneous colors from a palette of 4096. In computer-graphics applications, the chip generates RS-343A-compatible red, green, and blue video signals, including sync and blank, and drives doubly-terminated 75Ω coax directly, without requiring external buffering. Differential- and integral-linearity errors are less than ±1/16 LSB and ±1/8 LSB, respectively. The device dissipates 550 mW and operates over 0 to 70°C. In a 28-pin hermetic ceramic DIP, $26 (1000).

Brooktree Corp, 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580.

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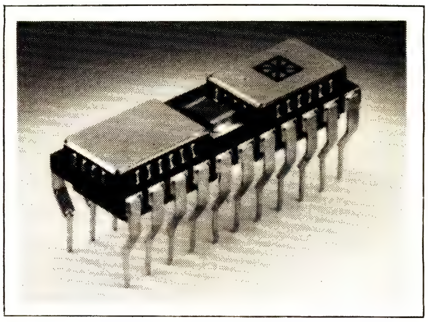
The 84H16C 16k×4-bit static RAM is now available in a military version (L suffix), which uses 6-transistor-cell CMOS technology. The high-speed RAM module, consisting of four 16k×1-bit RAMs, contains a decoupling capacitor and is housed in a 22-pin ceramic DIP. No clocks are required. The chip has $\overline{\text{CE}}$ power-down and data-retention functions: Data-retention current draw is 150 μA; standby current draw is 400 μA. The MIL-STD-883-screened module requires one 5V supply and comes in a 55- or 70-nsec version; prices are $195 and $150 (1000), respectively. Delivery, 12 to 14 weeks ARO.



Electronic Designs Inc, 35 South St, Hopkinton, MA 01748. Phone (617) 435-9077. TLX 948004.

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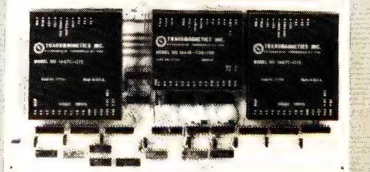

Single Speed tracking S/D or R/D modules are available with 16 bit resolution and ±40 arc seconds accuracy.

For stand-alone applications, low profile (.5") Model 5401C-20 incorporates a single 16 bit S/D converter and a reference supply. The user connects his transducer and the system is operational.

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PHONE NO. 516 293-3100 TWX510-224-6420

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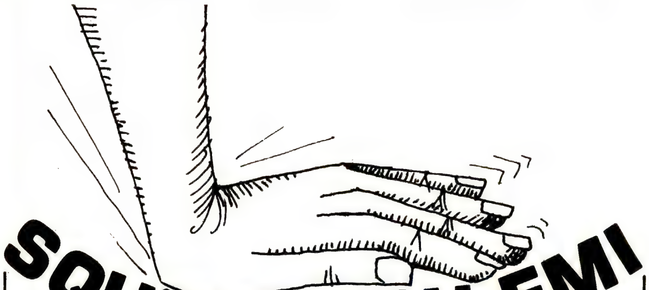

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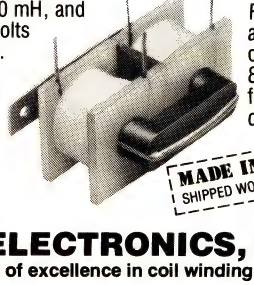

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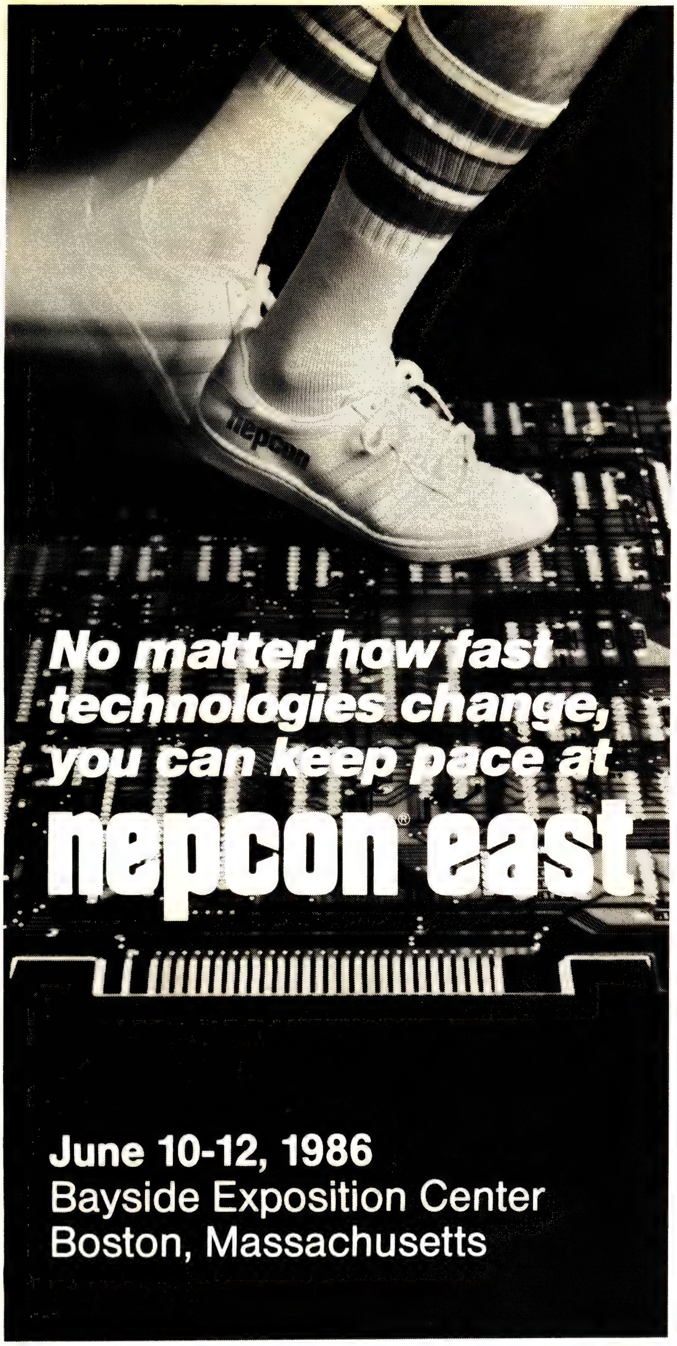
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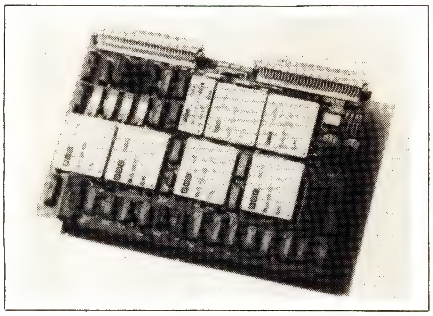

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ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 510-228-7324.

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Controlex Corp, 16005 Sherman Way, Van Nuys, CA 91406. Phone (818) 780-8877.

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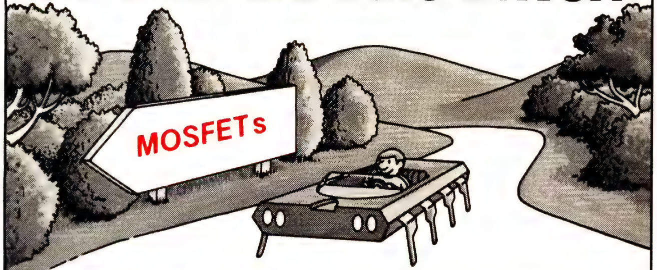

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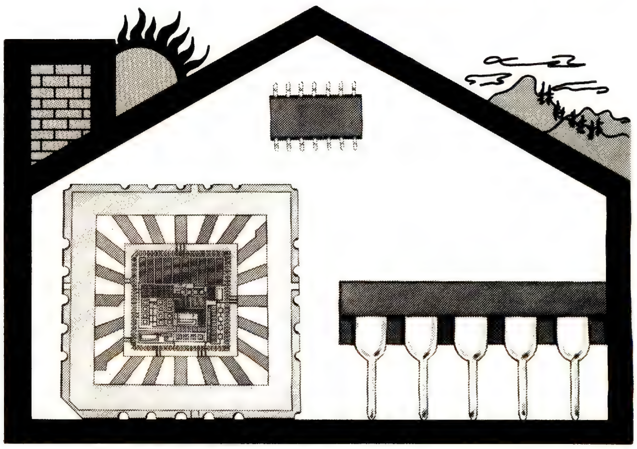

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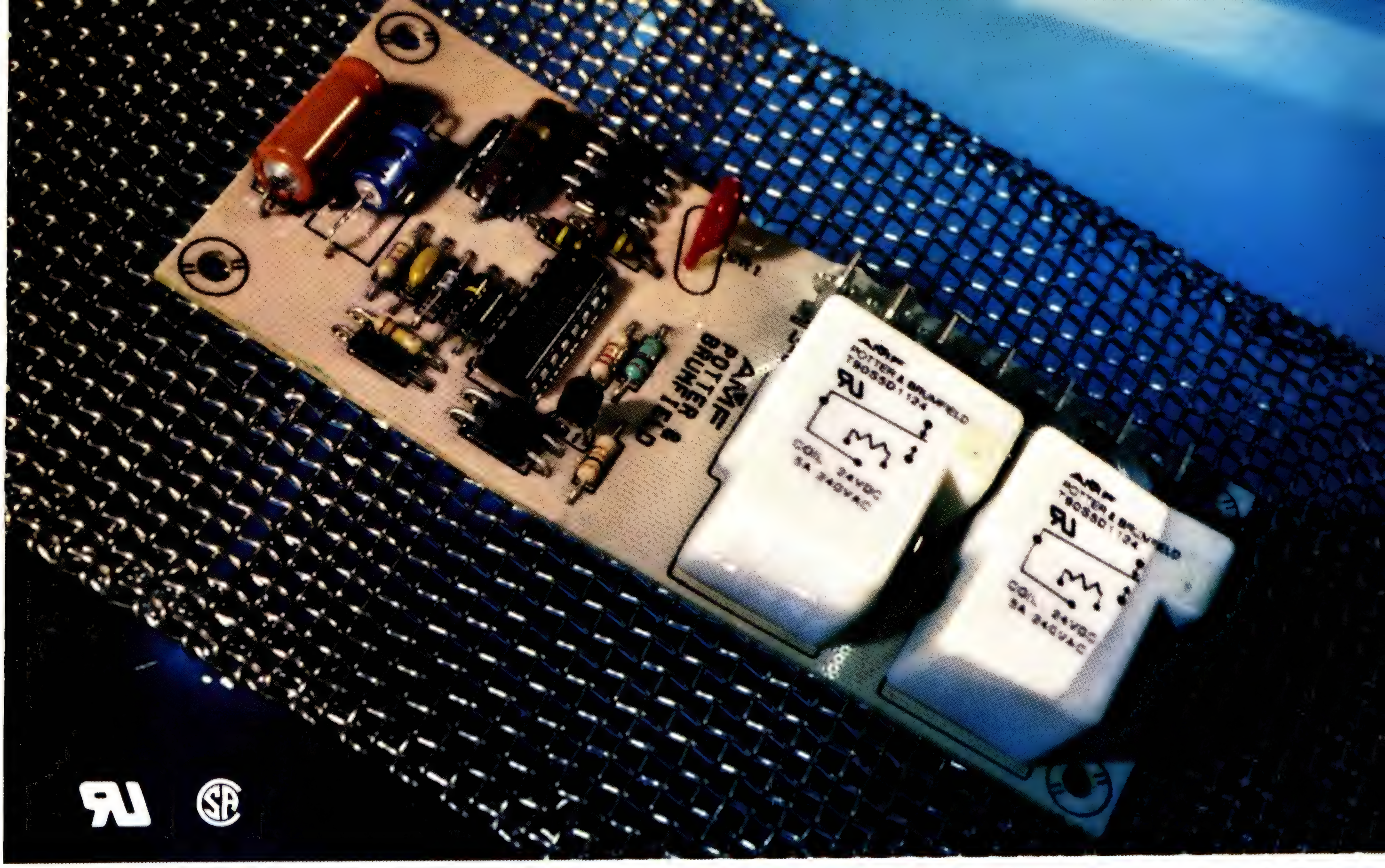

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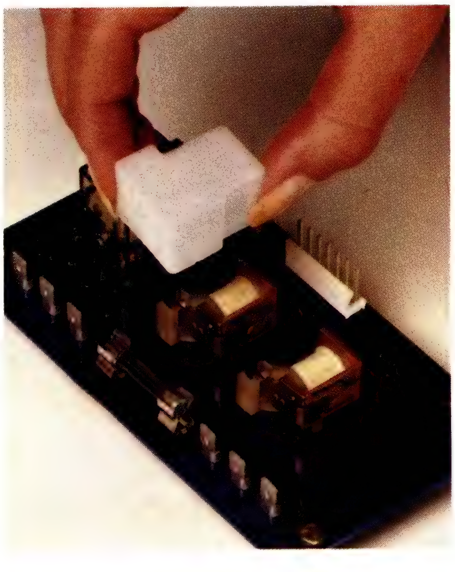

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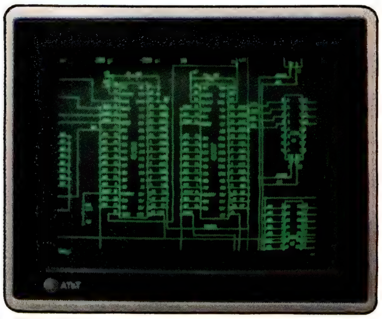

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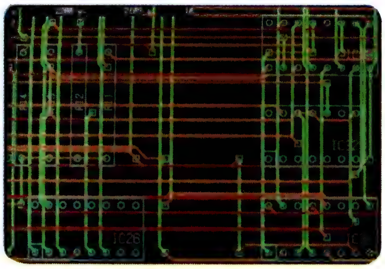

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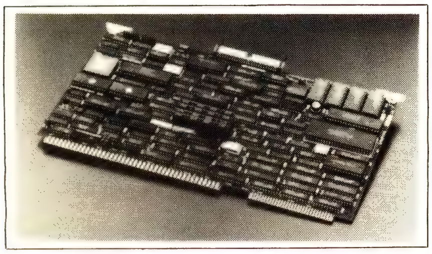
Micro Power Systems Inc, Telecommunications Div, 3100 Alfred St, Santa Clara, CA 95054. Phone (408) 727-5350.

Circle No 433



I/O CONTROLLER

The Protocol 1000 processes as many as 16 channels of full- or half-duplex serial data communications at 64k bytes/sec. The device features two processors, 512k bytes of triple-ported memory, and software from Brice Systems Inc (Great Falls, VA). The device provides as many as 16 channels of full- or half-duplex communications including a variety of standard and custom protocols, with support for X.25, Bisync, 3270, 2780, and 3780. An MC68010 µP handles protocols, commands, and buffer management; a 5-MIPS microcontroller acts as both an intelligent DMA and a serial bit-stream controller. $2750.

Interphase Corp, 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000. TLX 732561.

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MEMORY BOARDS

The Tripleplay Series multifunction memory boards add as much as 3M bytes of RAM to the IBM PC/AT. Each model comes with one serial port and one parallel printer port. The 2M- and 3M-byte models come with a memory-expansion adapter and an optional piggyback board that accommodates as much as 1.5M bytes of additional RAM. Four models with varying amounts of memory are available: 128k bytes, $295; 512k bytes, $395; 2M bytes, $795; and 3M bytes, $995.

Data Technology Corp, 2775 Northwestern Parkway, Santa Clara, CA 95051. Phone (408) 496-0434. TWX 910-338-2044.

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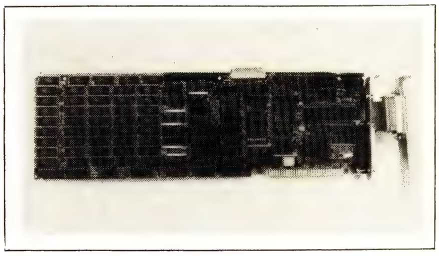

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Megafunction is an add-on board that combines standard multifunction features with a 1.25M-byte RAM disk for IBM PCs and compatible computers. In addition to the RAM disk, the device offers a paral-

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lel printer port, a serial port, and a clock/calendar. An auxiliary power supply makes the RAM disk nonvolatile even after the computer is shut off. The board can boot Lotus 1-2-3 in 2 sec, and it can save a file in 3 sec. In addition, routines in onboard ROM let you boot your system from the RAM disk. $895.

Tecmar Inc, 6225 Cochran Rd, Solon, OH 44139. Phone (216) 349-0600. TLX 466692.

Circle No 436

SERVO CONTROLLER

The EPX-01 single-width iSBX-compatible board provides the hardware necessary to add one axis of motion control to a standard Multibus board. This device accepts either incremental or 16-bit-differential absolute feedback. It provides a 12-bit D/A-converter/power-amp combination that can drive a variety of devices in either current or voltage mode. You can use several of these controllers in combination with a single-board computer. $299.

Inovec, 115 Wallis St, Eugene, OR 97402. Phone (503) 485-7127.

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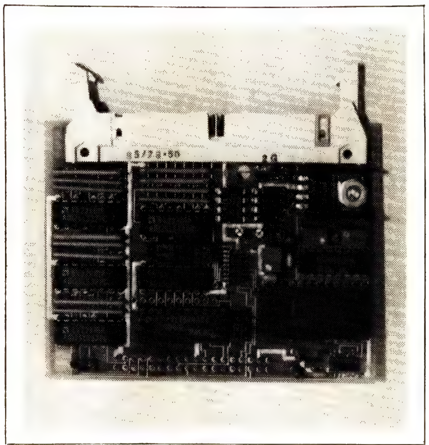

PC/XT-COMPATIBLE SBC

Fully compatible with the IBM PC/XT, the Quark/PC single-board computer mounts on a 5.25-in. floppy-disk drive. The board includes 256k bytes of dynamic RAM, a 4.77-MHz 8088 CPU, two serial ports, a parallel-printer port, a floppy-disk controller, a color-graphics CRT controller (which can also be used with a composite-input monochrome monitor), and a BIOS that boots MS-DOS version 3.0. Options include the PC/XT disk controller, a real-time clock, a bus-expansion module, a bus-expansion board, an additional 256k bytes of dynamic RAM, an 8087 math coprocessor, and the use of a 9.5-MHz 8088. $495.

Megatel Computer Technologies, 150 Turbine Dr, Weston, Ontario, Canada M9L 2S2. Phone (416) 745-7214. TLX 06527453.

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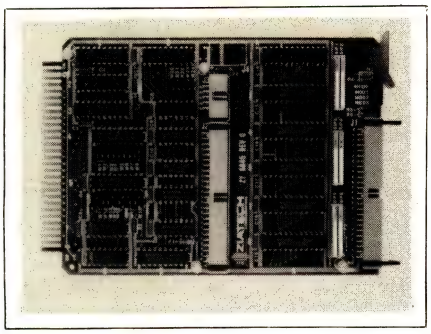
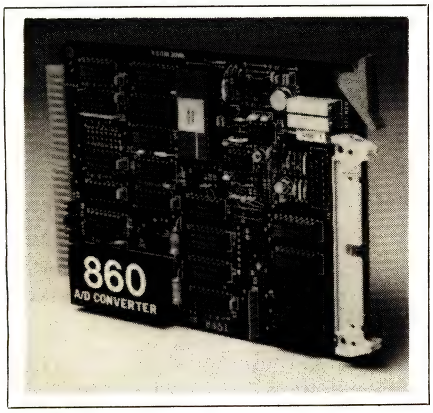


other digital devices to the STD Bus. You can designate four of the lines as event-sensing inputs that use interrupts to signal to the STD Bus system when an event occurs. The four interrupt lines can form an interrupt vector that is compatible with 8088, 80188, 8085, and Z80 µPs. The I/O channels sink 28 mA. $350. Delivery, four to six weeks ARO.

Ziatech Corp, 3433 Roberto Ct, San Luis Obispo, CA 93401. Phone (805) 541-0488. TLX 4992316.

Circle No 439



ANALOG INPUT CARD

Model 860 is an STD Bus card that provides 12-bit resolution for 16 single-ended-input or eight differential-input channels. You can double the number of channels in both instances. The card includes an S/H amplifier, a programmable-gain amplifier with user-configurable gain from 1 to 1000, a 25-µsec A/D converter, and an isolated dc/dc converter that operates from the STD Bus 5V supply. The 860's maximum throughput rate is 25k samples/sec. You can select by jumper either a

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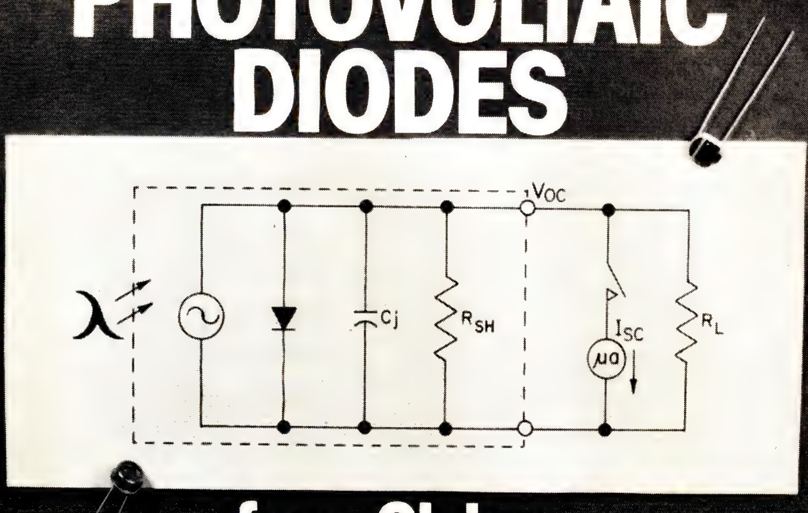

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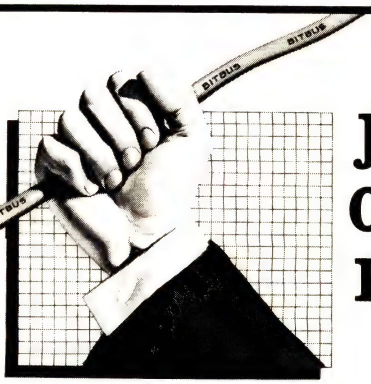

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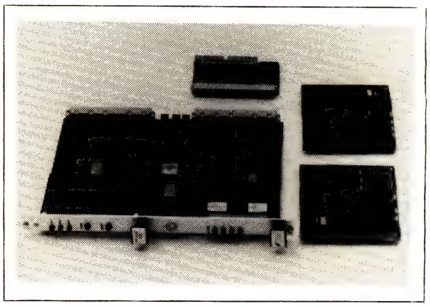
memory-mapped or an I/O-port interface to the STD Bus system. The card is compatible with all STD Bus μPs. You can also control it with commands in the high-level languages resident on the vendor's CPU cards. $565.

Octagon Systems Corp, 6501 W 91st Ave, Westminster, CO 80030. Phone (303) 426-8540.

Circle No 440



VME BUS SBC

The PT-VME102 single-board computer contains connectors into which you can plug one of various I/O Paks (I/O modules). On the board, a 68010 μP has access to 512k or 2M bytes of RAM and as many as 256k bytes of EPROM for program memory. The board also contains two RS-232C I/O channels, front-panel status LEDs, a system controller with a 4-level bus arbiter, seven levels of interrupts, and a clock/calender with battery backup. I/O Paks are available for the following ports: dual, quad, or hex RS-232C; dual or quad RS-422 with DMA capability; SCSI; and parallel I/O. In addition, the manufacturer offers an I/O Pak that interfaces with the 68881 floating-point processor. The board runs the P-DOS real-time operating system. The company's PT-SYS102 real-time development system provides a stand-alone development environment. PT-VME102 with 512k-byte RAM, $2195; PT-SYS102, $7950.

Performance Technologies Inc, 300 Main St, East Rochester, NY 14445. Phone (716) 586-6727.

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PMI'S CMOS DAC FAMILY HAS TWINS.

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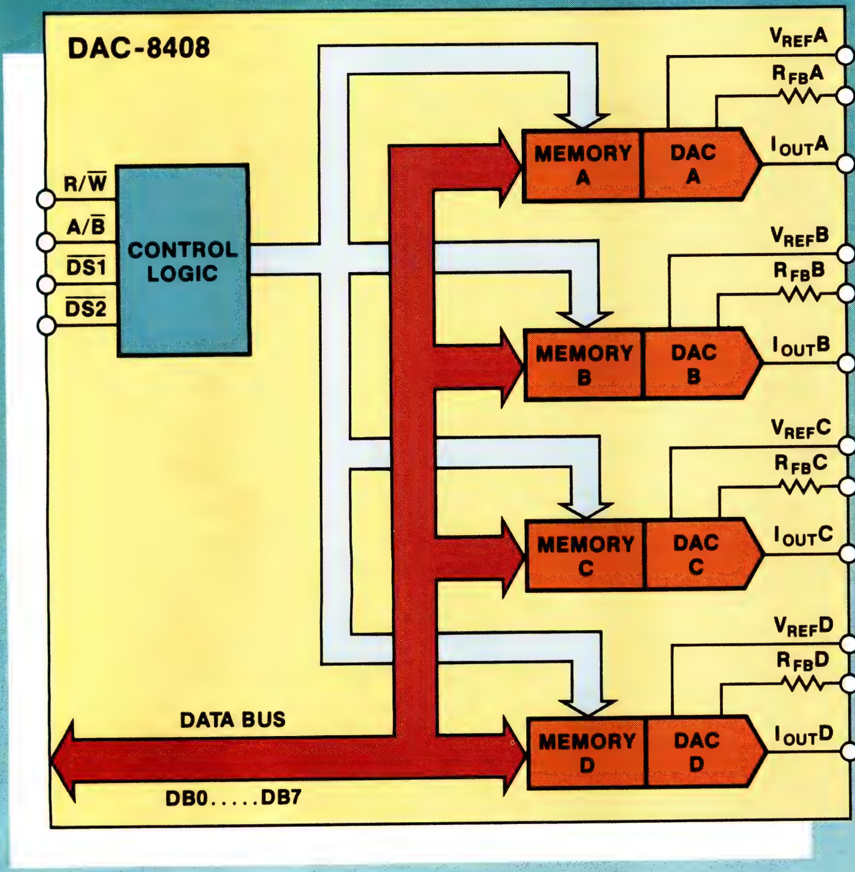

PMI's new DAC-8408, quad 8-bit D/A converter, tests system integrity using internal readback memory. Saving space and minimizing bus transactions, it simplifies data verification and system self-diagnostics.

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95054-3499
(408) 727-9222

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PMI's CMOS DAC FAMILY

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PM-7528	Dual Latched 8-bit
PM-7533	10-bit Multiplying
PM-7541	12-bit Multiplying
PM-7545	Latched 12-bit
PM-7645	Latched 12-bit
DAC-8012	12-bit Memory
DAC-8408	Quad 8-bit Memory
DAC-8212	Dual Latched 12-bit

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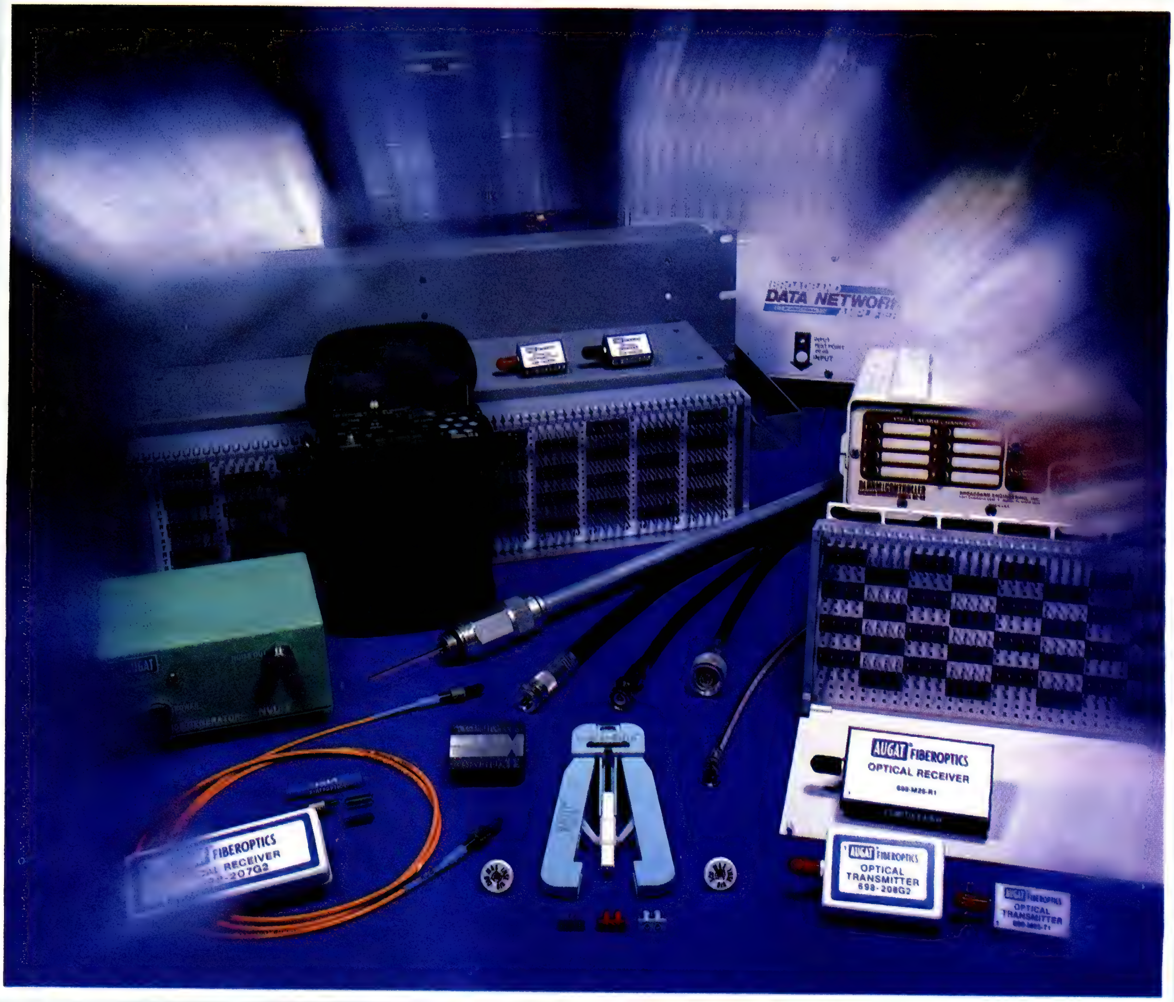

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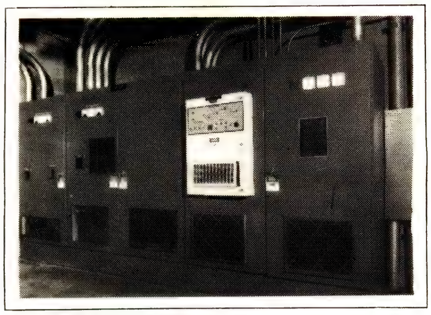
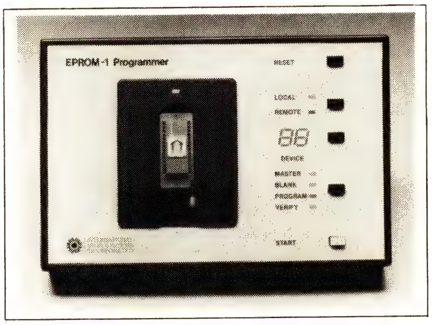


1000-kVA UPS

This uninterruptible power system (UPS) consists of a single-module, hybrid UPS with rectifier/charger, inverter, and rotary filter connected in series. The on-line inverter design, with natural commutation, provides the lowest parts count possible for maximum reliability, according to the manufacturer. The positive isolation provided by a separate generator blocks high-frequency noise and lighting surges that may occur on the utility. The systems are also available in 500-, 625-, and 750-kVA modules; they each can be paralleled for higher capacity or for redundant operation. $105,000. Delivery, 22 weeks ARO.

Power Systems & Controls, 3206 Lanvale Ave, Richmond, VA 23230. Phone (804) 355-2803. TLX 62776247.

Circle No 392



EEPROM PROGRAMMER

The Eprom-1 programs all standard NMOS and CMOS EPROMs/EEPROMs with capacities as high as 512k bytes. You can also upgrade it to support the latest EPROM devices. The programmer ensures that parts are correctly socketed and programmed, and it uses manufacturer-approved programming algorithms. No additional hardware is required. The standard buffer RAM is 64k×8 bits; 128k×8 bits is optional. A no-charge software package, which provides editing capabilities for IBM PC users, is included. $495.

International Microsystems Inc, 11554 C Ave, Auburn, CA 95603. Phone (800) 325-6028; in CA, (916) 885-7262.

Circle No 393

16-BIT DIGITIZERS

Models 650 and 652 are plug-ins for the company's Data 6000. Model 650 provides 16-bit resolution at sample rates to 1 MHz and has the ability to measure as many as four channels simultaneously at reduced sampling rates. Model 652 is limited to 2-input channels. You can select from

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- Vibration and shock damping!
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No matter what your p.c. card guide requirement, there's a UNITRACK solution. Mounting in cages or chassis is simple . . . UNITRACK's wide range of sizes in each type have either snap-in buttons or counterbored holes for rivet or bolt mounting.

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UNITRACK's Series 300 and 400 p.c. card guides are precision molded of stable polycarbonate plastic. Series 300 mounts on .300 centers for dense packaging. Series 400 mounts on .400 centers. Snap-in buttons or counterbored holes for mounting.

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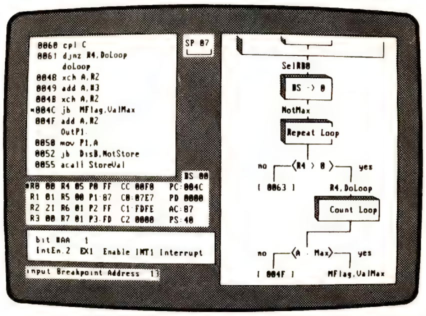
CIRCLE NO 140

IBM-PC based microcomputer development tools!



```
 0060 cpl C
 0061 djnz R4,DoLoop
      doLoop
 0048 xch A,R2
 0049 add A,#3
 004B xch A,R2
*004C jb  MFlag,ValMax
 004F add A,R2
      OutP1
 0050 mov P1,A
 0052 jb  DisB,NotStore
 0055 acall StoreVal
```

```
SP 07
BS 00
*R0 00 R4 05 P0 FF  CC 00F0   PC:004C
 R1 01 R5 00 P1 07  C0:07E7   PD 0000
 R2 21 R6 01 P2 FF  C1 FDFE   AC:07
 R3 00 R7 01 P3 FD  C2 0000   PS:40
```

```
bit #AA   1
IntEn.2  EX1  Enable INT1 Interrupt
```

```
input Breakpoint Address  13
```

(8051 debug/simulator shown)

Your IBM PC can Assemble, debug and program (EPROM) code for these popular microcomputers:

	dBUG	XASM	PROG
8096	✓	✓	✓
8051	✓	✓	✓
8049	✓	✓	✓
7000	✓	✓	✓
8088	✓		✓
8085		✓	✓
320		✓	✓
Z8		✓	✓
	$595 except 8096 and 8088	$295	$245 Kit form

Step your code, watch registers & memory change, interrupts occur, stack push & pop. Flowgraph auto-documents code! You set breakpoints & register traps, count machine cycles, and scan source code and symbols. Single-key commands prompt for arguments if needed. Have more fun and get more done!

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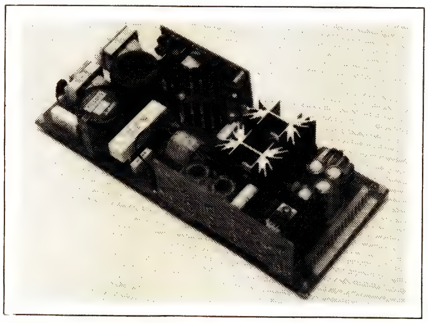
CIRCLE NO 141

the six full-scale ranges available independently on any channel from ±500 mV to ±20V. The Data 6000 provides display and analysis of the acquired data. It can extract most commonly sought scalar-waveform parameters, and perform signal averaging, convolution, correlation, spectrum analysis, and other signal-processing functions. 4-channel version, $12,800; 2-channel version, $9995. Delivery, 60 days ARO.

Data Precision, Div of Analogic, 16 Electronics Ave, Danvers, MA 01923. Phone (617) 246-1600. TLX 921819.

Circle No 394



200W SUPPLY

The Tiger-200 4-output switching power supply measures 3.9×8.5×2 in. Overload and overvoltage protection are standard features; remote voltage sensing, remote shutdown, and power-fail detect are optional features. The supply is available with or without a line filter. The device meets UL, CSA, and VDE standards. $220 (100).

Pacific Power Technology Inc, 8921 Murray Ave, Gilroy, CA 95020. Phone (408) 848-1816. TLX 294233.

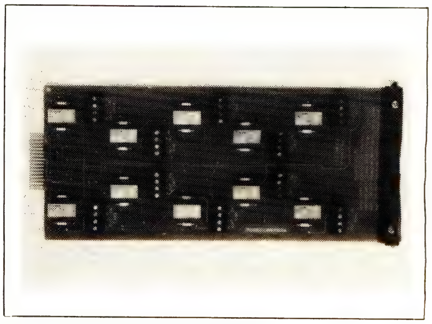
Circle No 395

PULSE GENERATOR

The Model PG 4000A pulse generator operates at pulse repetition rates of 10 MHz to 4 GHz. Its rise/fall time is 30 to 50 psec at rates higher than 2 GHz, and 70 to 120 psec at rates lower than 2 GHz. The generator has differential outputs whose transition times are matched to within 10 psec over 2 to 4 GHz and to within 20 psec below 2 GHz. Output amplitude is 2V max, but a higher-power 2.5V option is available with a slight degradation in rise/fall time. Output-amplitude attenuation, using microwave attenuators, is 0 to 20 dB in 1-dB steps. You can set each output's amplitude independently (except for the 1-dB fine control); a digital display indicates the output with 10-mV resolution. The output-amplitude setting is independent of the dc output-offset setting, which you can adjust over a ±5V range. By changing the sinusoidal-input drive level, you can vary the outputs' rise and fall times. $14,500; 2.5V-output option, $4500.

Colby Instruments Inc, Box 84379, Los Angeles, CA 90073. Phone (213) 450-0261.

Circle No 396



SCANNER CARD

The 7066 relay-switch card provides 10 independent and isolated channels for nonmultiplexed switching. Each channel has form A contacts but, if necessary, you can reconfigure them for form B or C contacts by relocating jumpers. The contacts can handle voltage and current levels within the limits of 2A max, 350V max, and 125 VA max. Wire

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Mepco/Electra Inc., 6071 St. Andrews Road, Columbia, S.C.

PHILIPS Electronic components and materials

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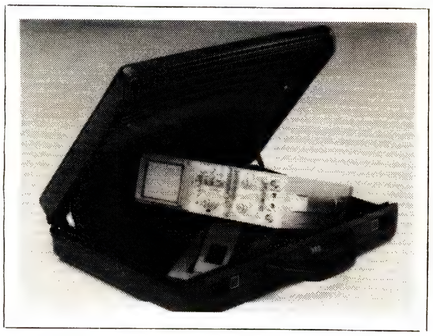
PHILIPS

terminations allow quick-disconnect from the card. The card plugs into either of the company's scanner mainframes: Model 705 (two card slots) or Model 706 (10 card slots). $295.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

Circle No 397



TINY SCOPE

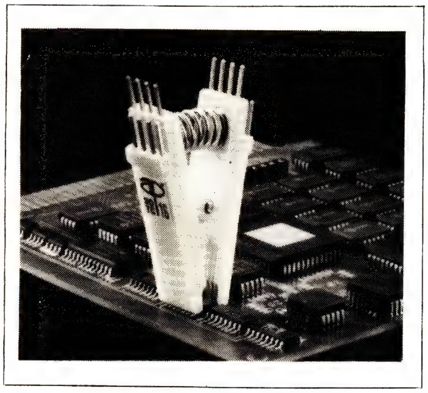
The LBO-325 2-channel, 60-MHz oscilloscope has a 3-in. die-cast aluminum frame, weighs 8.5 lbs, and has an 8×10-division, 3.5-in. rectangular CRT with an internal graticule. The dual time base offers calibrated-delay and alternate-sweep timing modes. Triggering capabilities include alternate triggering, video sync separators, variable trigger hold-off, and level and preset controls. The scope's vertical-input section offers add and subtract modes with 1-mV sensitivity. A signal-delay line is included to allow observation of sharp leading edges. $1500.

Leader Instruments Corp, 380 Oser Ave, Hauppauge, NY 11788. Phone (800) 645-5104; in NY, (516) 231-6900.

Circle No 449

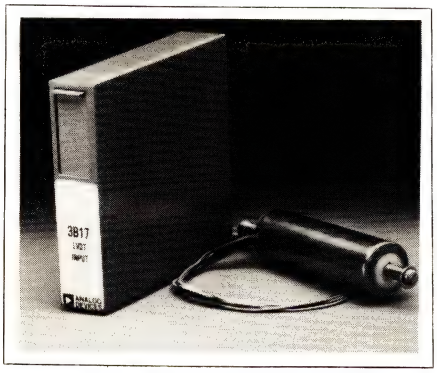
TEST CLIPS

Each test clip in the SOIC Series provides quick access to all the terminals of a small-outline integrated-circuit (SOIC) package. The series includes clips with eight, 14, or 16 contacts for 0.15-in.-wide SOIC packages and clips with 16, 18, 20, 24, or 28 contacts for 0.30-in.-wide SOIC packages. Staggered contacts allow you to attach test leads easily, and an insulating comb prevents accidental shorts to adjacent probes or other circuit components. You can wire-wrap or attach female connectors to the industry-standard 0.025-in. contact pins. Further, the test clips will attach to SOIC packages that are mounted 0.025 in. apart at the ends. You can specify either gold-plated leads or alloy 769 nickel-silver leads; body material is acetal thermoplastic. Clips for 0.15-in.-wide SOIC packages, $6.27 to $13.46; clips for 0.30-in.-wide SOIC packages, $6.84 to $27.66.



A P Products Inc, Box 540, Mentor, OH 44060. Phone (800) 321-9668; in OH, (216) 354-2101. TWX 810-425-2250.

Circle No 450

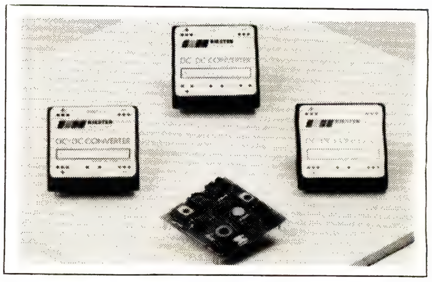


LVDT CONDITIONER

The 3B17 plug-in signal-conditioning module provides an ac excitation signal to an LVDT (linear variable differential transformer) or RVDT (rotary variable differential transformer), conditions the transducer's low-level ac output signal, and produces high-level dc voltage and current outputs. The module plugs into the company's 3B signal-conditioning subsystem and accepts inputs from 4-, 5-, and 6-wire LVDTs and RVDTs, and provides outputs of ±10V, 4 to 20 mA, and 0 to 20 mA. The excitation range is 1 to 5V with a 20-mA rms-current limit and a 10-kHz frequency limit. Input, current-output, and excitation circuitry are protected against continuous overvoltage to 130V rms. The conditioner specs 0.1% of span typical accuracy, ±0.005% of span/°C offset drift, and ±0.01% of span/°C span drift. Operating temperature range is −25 to +85°C. $225.

Analog Devices, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-4019.

Circle No 398



DC/DC CONVERTERS

The DD 5WLC Series of pc-board-mounted 5W dc/dc converters comes in 2×2×0.4-in. encapsulated packages with industry-standard pinouts. Input voltages are 5, 12, 24, 48, and 60V dc. These nine standard-output converters include single-output models of 5, 12, 15, and 24V dc; dual-output models of ±5, ±12, ±15V dc; and triple-output models of 5/±12 and 5/±15V dc. Specifications common to all units include ±3% output accuracy, ±1% line and load regulation, 20-mV p-p ripple and noise, and 500V dc I/O isolation. Single-output models cost $42.11 (100). Delivery of OEM orders, eight to 10 weeks ARO.

Brandner Inc, Box 822, Framingham, MA 01701. Phone (617) 655-8982. TWX 510-100-3630.

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THE BEST.

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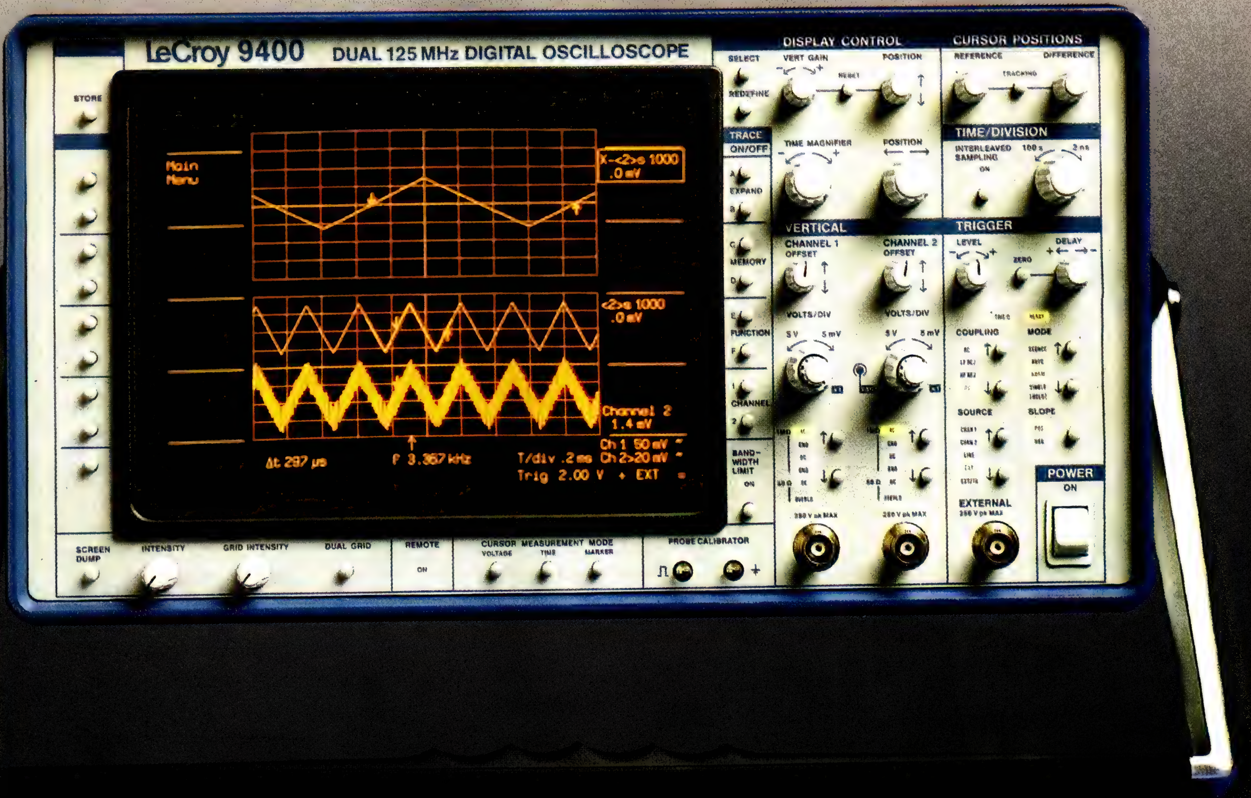

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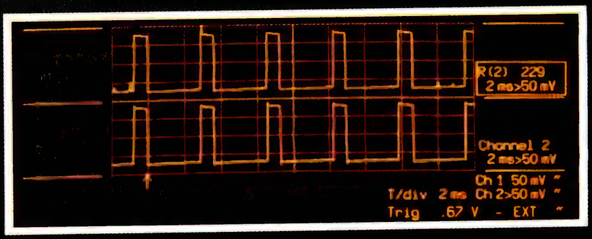
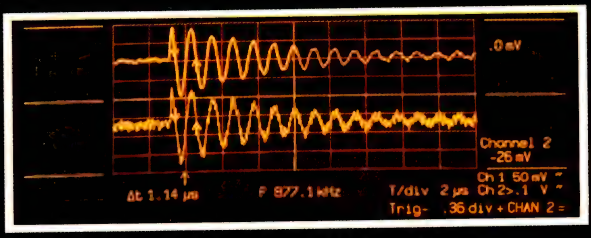
★And there is much more to say about this versatile and cost effective ($ 9900 base*) DSO. **Call us now...for details and a demonstration!!**

*USA price list only.





Top: Summation averaging over 1,000 waveforms, expansion and high resolution frequency measurement all shown in one display.

Middle: Extrema Mode shows glitches in digital circuitry, logged over 229 acquired waveforms.

Below: Digital filtering with a 9-point filter smooths noisy transient.

LeCroy

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CIRCLE NO 145

CMOS µP

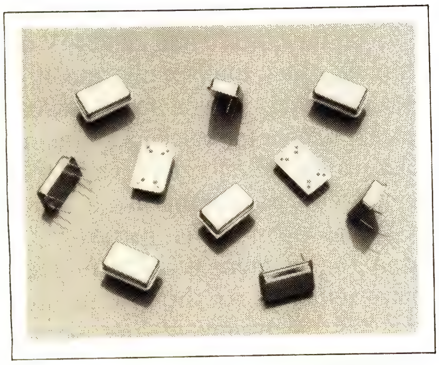
Pin- and software-compatible with the NMOS Z80 µP, the CMOS Z84C00 µP draws less than 15 mA typ when active, and only 10 µA in power-down mode. These specifications apply over the −40 to +85°C operating range. The µP is available in 2.5-MHz and 4-MHz versions, with a 6-MHz version to follow shortly. Other family devices available as CMOS parts include the Z80-PIO, Z80-CTC, and Z80-SIO. The M8719, a CMOS clock-generator/divider, is also available. Z84C00 CPU, approximately $2.80 (1000).

SGS-Ates, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (39) 65551. TLX 330131.

Circle No 400

SGS-Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100.

Circle No 401



CRYSTAL OSCILLATORS

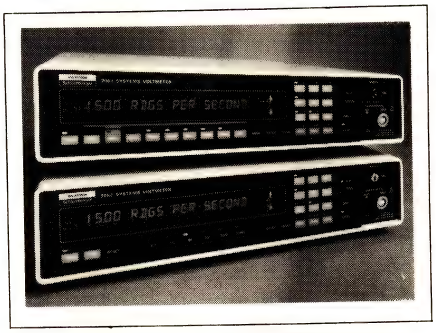
Crystal oscillators in the QCO-2000 line include TTL-compatible transistor oscillators, TTL-compatible gated oscillators, and CMOS-compatible versions. All types have a standard stability rating of ±100 ppm, which includes variations over temperature range, supply voltage, and time. Stabilities of ±500 ppm and ±50 ppm are available by special order. Transistor oscillators come in standard frequency values between 250 kHz and 70 MHz; gated oscillators between 4 MHz and 60 MHz; and CMOS versions between 62.5 kHz and 20 MHz. The transistor and gated-oscillator versions operate from 5V supplies, spec a 20-msec max start-up time, and draw a maximum of 40 mA and 25 mA, respectively. The CMOS-compatible oscillators operate from 3 to 6V supplies, start up in 1.5 msec max, and draw 4 mA max. All devices operate over a 0 to 70°C range and are housed in hermetically sealed metal packages. From £2.13 to £3.38 (1000).

STC Components Ltd, Quartz Crystal Unit, Edinburgh Way, Harlow, Essex CM20 2DE, UK. Phone (0279) 26811. TLX 818746.

Circle No 402

Stantel Components, 636 Remington Rd, Schaumberg, IL 60195. Phone (312) 490-7150.

Circle No 403



DIGITAL MULTIMETERS

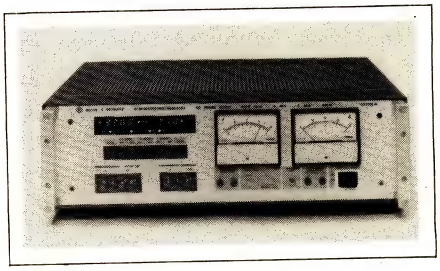
The 7061 and 7062 digital voltmeters both achieve a measurement rate of 1500 readings/sec at 4½-digit resolution, dumping as many as 1000 readings (8000 with an expanded memory option) into internal memory. Operating on the IEEE-488 bus, the instruments offer a continuous-read rate as high as 400 readings/sec; they can initiate and transmit a 4½-digit reading within 3 msec of receiving an external hardware or software trigger. Response time to out-of-limit alarm conditions is <1 msec. An optional reed-relay scanner adds sixteen 2-pole or eight 4-pole input channels to the instrument's standard signal- and reference-input channels. You can progressively increase the voltmeters' integration time to 2 sec and thus obtain measurement resolutions between 4½ and 7½ digits. At the point of 6½-digit resolution, the voltmeters have a maximum dc-input sensitivity of 100 nV. DC and ac current are measured with 1-µA and 10-µA resolution, respectively, on a nominal 2000-mA range. Used with a platinum resistance thermometer, the 7061 allows you to measure temperature with a resolution of 0.001°C. Other features of the 7061 are ratiometric measurement between any two functions, math programs for postprocessing of measured data, line-locked integration periods, and lids-on digital calibration. The 7061, £2495; the 7062, £2295.

Solartron-Schlumberger, Victoria Rd, Farnborough, Hampshire GU14 7PW, UK. Phone (0252) 544433. TLX 858245.

Circle No 404

Solartron Instruments, 2 Westchester Plaza, Elmsford, NY 10523. TLX 145487. Phone (914) 592-9168.

Circle No 405



POWER SUPPLY

The NGPE-40/40 programmable power supply provides output voltages and currents as high as 40V or 40A with a resolution of 10 mV and 100 mA, respectively. Maximum permissible load power extends to 15V/40A, 25V/27.5A, and 40V/20A. You can set parameters either via digital switches on the front panel or via the unit's IEEE-488 interface. Actual output conditions are displayed separately on analog voltage and current meters. You can remotely sense the output with separate sense leads; automatic switchover from local to remote sensing occurs after the addition of sense leads. The maximum voltage compensation for each lead is 0.5V. Voltage- and current-monitoring outputs are also provided. The unit is packaged in a 19-in.-wide housing. DM 6500.

Rohde & Schwarz GmbH & Co KG, Mühldorfstr 15, 8000 Munich 80, West Germany. Phone (089) 41292625. TLX 523703.

Circle No 406

Rohde & Schwarz Inc, 13 Nevada Dr, Lake Success, NY 11042. Phone (516) 488-7300.

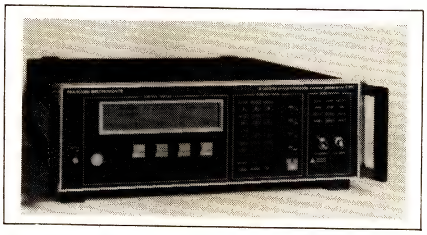
Circle No 407

FIBER-OPTIC TESTERS

Both these handheld portable instruments, the 7740 calibrated laser transmitter and the 7741 radiometer, allow field testing of the attenuation of optical fibers. The 7740 produces 1 mW of laser power at a wavelength of 840 nm and has a long-term power output stability at constant temperature of <1%. A key-operated safety switch shuts off the laser independently of the unit's power supply. You can operate the 7740 either from a 220V ac line supply or from the transmitter's internal rechargeable batteries. The 7741 radiometer measures received optical power in the wavelength range of 0.8 to 1.6 μm with a maximum resolution on its 200-nW range of 100 pW. The meter has five ranges between 200 nW and 2 mW, with measured optical power displayed on a 3½-digit LCD. Thermoelectric cooling of the photodiode detector to −15°C helps achieve a dynamic range of >70 dB. A 2V full-scale analog output is provided for monitoring purposes. The 7741 requires a 230V ac line supply. The 7740 transmitter and the 7741 radiometer operate over a 10 to 40°C temperature range. Both units measure 190×110×60 mm; they weigh about 1.3 kg each. The 7740, Fr fr 37,000; 7741, Fr fr 26,000.

Enertec-Schlumberger, 5 rue Daguerre, 42030 St Etienne Cedex 2, France. Phone (77) 252264. TLX 300796.

Circle No 408



SWEEP GENERATOR

The 6310 sweep-frequency generator produces outputs in the 2- to 20-GHz frequency range. The sweep period can vary between 10 msec and 33 sec. The generator has six basic modes of operation: three with calibrated, leveled output power and three with power-slope control. In the leveled modes, the output power has an overall accuracy of ±0.4 dB; its resolution is 0.01 dB. The generator's actual output power ranges from +20 to −15 dBm. The power-sweep mode varies the output power between preselected power levels in the −5- to +20-dBm range. From £18,000.

Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN, UK. Phone (0727) 59292. TLX 23350.

Circle No 409

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Phone (201) 934-9050.

Circle No 410

SHAFT ENCODERS

The 35HA family of optical absolute shaft encoders includes models with 14-, 16-, 18-, and 20-bit resolution. Internally controlled by a Z8 μP, the encoders output angular position, accuracy, address, and checksum data in a serial format. You can multiplex several encoders onto one serial interface. The encoders have an 80×90-mm cylindrical housing and require one 5V supply. A control and display unit, which can handle the outputs from as many as seven encoders, is also available. £1687 to £3375.

Ferranti Industrial Electronics Ltd, Thornybank, Dalkeith, Midlothian EH22 2NG, UK. Phone 031-663 2821. TLX 72197.

Circle No 411

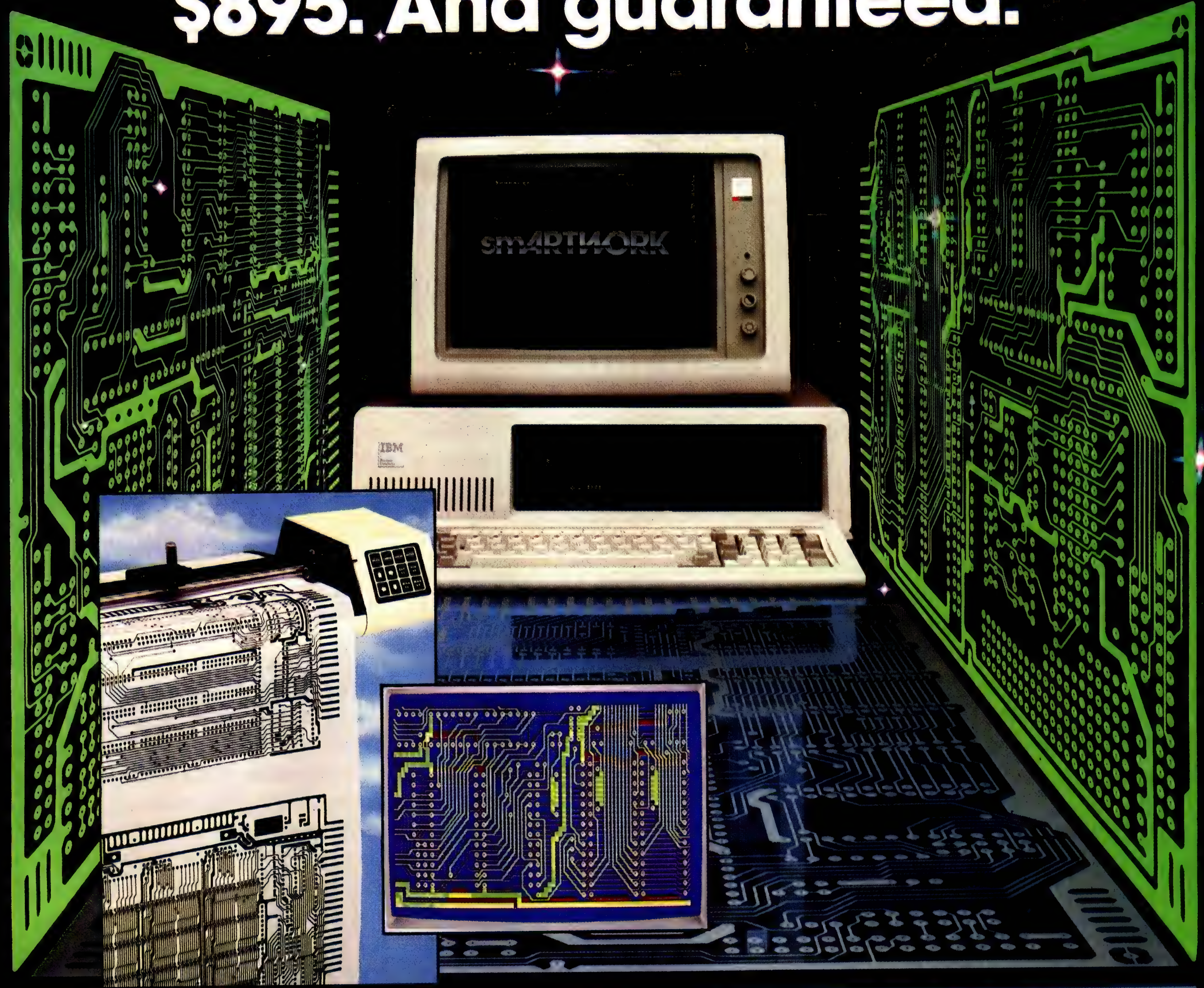
AC-SUPPLY MONITOR

Suitable for 110/120 and 220/240V ac supplies, this line-supply monitor measures and records spikes, sags, surges, dropouts, blackouts, undervoltages, overvoltages, and frequency deviations. You use a 4-line LCD and menu-driven soft keys to set up the instrument and to display measurements. An integral printer provides hard copy of line disturbances in tabular or graphic form, and you activate an audible alarm to sound on preset line conditions. The instrument detects and measures positive and negative spikes of >25V peak amplitude and between 40 nsec and 333 μsec in duration. Internal batteries maintain operation of the unit during blackouts and provide a 30-day backup for the unit's data memory. A real-time clock is also included. Operating range is −10 to +50°C. Options include an RS-232C serial interface for remote monitoring. £4700.

Cole Electronics Ltd, Bruce Grove, Wickford, Essex SS11 8BT, UK. Phone (03744) 5141. TLX 99252.

Circle No 412

Circuit-Board-Artwork Software: $895. And guaranteed.



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CIRCLE NO 146

80386 LIBRARIES

These IEEE floating-point libraries for the 80386, the FPAC (single-precision, 32-bit format) and the DPAC (double-precision, 64-bit format), perform basic operations at speeds comparable to an 80287. Running on a 16-MHz 80386, the FPAC performs as many as 100k flops, and the DPAC attains 70k flops. The libraries offer trigonometric functions (sine, cosine, tangent, arctangent), exponentiation functions, data-conversion procedures (ASCII to/from floating point and integer to/from floating point), and floating-point utility procedures. They include 80386 native (32-bit) assembly source code to allow simple customization and inclusion in user applications. The FPAC, $950; the DPAC, $1250.

United States Software Corp, 5470 NW Innisbrook Pl, Portland, OR 97229. Phone (503) 645-5043. TLX 4993875.

Circle No 413

DISK ORGANIZER

Disk Tuner is a software package for increasing disk efficiency in Unix systems. The package uses statistics on file-use frequency to optimize free-space placement on the disk and thereby minimize head movement during file accesses. The package contains a separate program for each of the three steps of the optimization process. The monitoring program collects i-node usage data from each file system in a usage database. The analysis program is run periodically to develop the file-layout strategy. The reformatting program implements the file-layout strategy, which is based on an algorithm that re-orders directories so that the most frequently used file names appear first; it then repacks, in a contiguous manner, the most used files near the head of the file system; next it moves recently neglected files and long-neglected files to the middle and outer portions of the file system, respectively. Written in C, the package runs on Unix System V, System III, Version 7, and Xenix. It is distributed on 9-track, 1600-bpi magnetic tape. $6000.

Aim Technology, 4655 Old Ironsides Dr, Suite 390, Santa Clara, CA 95054. Phone (408) 727-3711. TLX 705404.

Circle No 414

PRINTER UTILITY

Printkey, a memory-resident utility for IBM PCs, enhances communications between printers and software and provides access to advanced software-controlled printing features inaccessible from most applications software. The user creates macro commands, which are tailored to specific printers and tasks. Once you define the macro commands by equating a printer command string with a special character (called a macro character), you can invoke macro commands from within other software. The utility translates any macro characters it finds in a document into corresponding printer commands, which are then sent to the printer. You can also define macro keys on the keyboard, which allow you to send particular commands to the printer at any time. $89.95.

North West Software Associates, 12469 E Olive Ave, Spokane, WA 99216. Phone (509) 928-2361.

Circle No 415

INTERFACE PACKAGE

The dDCM810-R interface package allows you to connect an iRMX86 system with a Bitbus that provides communication with industrial-process-control and data-acquisition devices. The software works with the company's dDCM800 interface module or Intel's iSBX344 to provide an interface between Intel's 86/310 system application code, which resides within the iRMX86, and a Bitbus operating system. The software manages message packets, provides message protocol, matches a named interface to its peripheral device on the Bitbus, and offers user-specified flow control. $750.

Datem Ltd, 148 Colonnade Rd, Nepean, Ontario, Canada K2E 7R4. Phone (613) 225-5919. TLX 0533864.

Circle No 416

IMAGE PROCESSING

Mirage-128 interactive image-processing software runs on an IBM PC, PC/XT, or PC/AT with the company's IVG-128 real-time video-acquisition and -display module. Image-processing algorithms include such functions as image-capture and -display management, selection of regions of interest, image statistics, point processing, convolution filtering, edge detection, geometric transforms, linear kernel transforms, B&W image processing, and image compression. A multilevel interactive menu with on-line help facilities guides you through all functions. Additional features include turnkey operation and a linkable library; source code and executable code are also provided. Single-user license, $500.

Datacube, 4 Dearborn Rd, Peabody, MA 01960. Phone (617) 535-6644. TWX 710-347-0125.

Circle No 417

SERIAL CONTROLLER

The iRCB 44/20 Bitbus controller manages as many as 16 remote points. The module is based on the company's Bitbus serial bus architecture, which defines the interconnection of microcontrollers in distributed data-acquisition and control systems. Use of VLSI components provides reliability, improved system throughput, and lower cost, according to the company. The controller also features onboard preprocessing of analog data and the use of one twisted-pair wire between the Bitbus I/O controller and the host processor. It contains a 12-MHz 8044 microcon-

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CIRCLE NO 147

troller, 16 input channels, two output channels, and two 28-pin JEDEC memory sites on one Eurocard-style pc board. The iDCX Distributed Control Executive software contained in the 8044 microcontroller on the 44/20 provides real-time facilities for Bitbus-based products. $644 (100).

Intel Corp, Literature Dept, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (503) 640-7147.

Circle No 418

TEST PACKAGE

The Testview set of programs allows an IBM PC or compatible computer running under MS-DOS or PC-DOS to accept burn-in and test-system data either from disk or in real time through an RS-232C interface. The package creates databases from the data received, filters the data according to your criteria, and then summarizes the filtered databases into a user-defined spreadsheet. You can then use the spreadsheet to create tables and graphs, to which you can add text by using the integrated word-processing package. To run the package, you'll need 512k bytes of RAM. $4500.

RJI Strategic Partnering Group, 9809 Whithorn Dr, Houston, TX 77095. Phone (713) 859-0235.

Circle No 419

GRAPHICS LIBRARY

This library of graphics routines runs on the company's PC-100 array processor, which plugs into an IBM PC, PC/XT, PC/AT, or compatible computer. The library includes 2-D and 3-D algorithms for translation, scaling, rotation, reflections, projections, perspective transformations, reconstruction, cubic splines, and parabolic blending. It's written in assembly language, and you can link it with application programs written in C or Fortran. The library can use the enhanced color-graphics mode on the PC/AT and standard color- and monochrome-graphics modes on the PC/XT. $495.

Systolic Systems Inc, 1065 E Brokaw Rd, San Jose, CA 95131. Phone (408) 286-0421.

Circle No 420

BASIC MODULE

BWS Basic is a multitasking Basic interpreter that runs on the company's 7806 Z80-based CPU card for the STD Bus. The interpreter handles standard Basic commands and contains features that allow you to create and execute in real time a Basic program that controls and monitors as many as 16 tasks simultaneously. Those features include Whent and Whenp, which check the timing and I/O-port values before executing a task. The Auto command provides automatic execution of a program when the power comes on or when the system is reset. Access to the real-time clock eliminates the need to generate software timing routines. The 7806 card features a Z80 processor, two RS-232C ports with cable, and four memory sockets—two for system use and two for application RAM or ROM. You can connect the subsystem to a host computer via the serial ports and cable. Once you create a program, you can execute it on the STD Bus target system or download it to a PROM programmer. Software, $150; 7806 card, $340.

Pro-Log Corp, 2411 Garden Rd, Monterey, CA 93940. Phone (408) 372-4593. TWX 910-360-7082.

Circle No 421

OCR SOFTWARE

Two versions of the Character Image Recognition (CIR) software, CIR I and CIR II, allow you to achieve recognition of most fonts commonly found in business. The software operates with the company's Series 700 scanners and runs on the IBM PC. CIR I recognizes the standard typewriter and printer fonts used in most offices. The program also has an interactive capability: When CIR I doesn't recognize a character, it displays the character in context, and the user enters the appropriate letter, thus teaching CIR to identify that character. You can instruct the CIR II package to recognize a new font quickly. In the interactive learn mode, the software displays each character; you identify the character by pressing the appropriate key on the keyboard. You can also instruct CIR II in a batch learn mode. CIR I, $695; CIR II, $1995.

Datacopy Corp, 1215 Terra Bella Ave, Mountain View, CA 94043. Phone (415) 965-7900.

Circle No 422

C CROSS COMPILER

The Intel 8051 cross compiler package includes a compiler, an assembler, and a linker; you use it to write programs for the Intel 8051 on a Unix host and then cross-compile the programs to the target μP. Features include a stack frame to minimize overhead, separate compiling and linking, an optimizer, and a run-time library. Register declarations use microcontroller hardware registers to produce efficient code. The package runs under Xenix System V on an IBM PC/AT or compatible. Other versions are available for the VAX and MicroVAX, Sun workstations, AT&T 7300 (3B1) and 3B2 systems, and the Plexus P-35 and P-60. $3500.

Specialized Systems Consultants Inc, Box 55549, Seattle, WA 98155. Phone (206) 367-8649.

Circle No 423

FILE TRANSFER

The FTP (file-transfer program) package, which supports the TCP/IP (transmission control protocol/internet protocol), now runs on DEC's RT-11 OS. (The company already offers versions for Micro/RSX, RSX-11M, and RSX-11M-Plus systems.) The software transfers files between different Unix-based computers and workstations that also support the TCP/IP. It operates with DEC's DEQNA Ethernet network controllers and includes a utility for user-initiated file transfers as well as a program to turn any RT-11-based system into an unattended file server. $995.

Process Software Corp, Box 746, Amherst, MA 01004. Phone (413) 549-6994. TLX 517891.

Circle No 442

COMPATIBILITY TEST

The PC-Test suite of tools verifies design compatibility of PC-related hardware products with an IBM PC/XT or PC/AT. The 160 tests fall into two groups: One group verifies low-level hardware design and ROM BIOS routines; the other examines the DOS to BIOS interfaces used by the operating system. All of the tests have been developed from the IBM technical reference manuals for the PC, PC/XT, and PC/AT. The package includes source code for all tests. PC/XT version, $11,000; PC/AT version, $22,000.

Award Software Inc, 236 N Santa Cruz Ave, Los Gatos, CA 95030. Phone (408) 395-2773.

Circle No 443

SOLIDS MODELER

AC/Solids is a 3-D solids modeler that allows you to incorporate doubly curved surfaces into your drawings. This package produces a 3-D solids model from either a surface model or a 2-D outline. It includes a selection of primitives and Boolean operations for model building. You can view the completed model from any vantage point, with hidden lines displayed or suppressed, and carry out engineering calculations such as a part's mass, surface area, or center of gravity at any time. Also included are features to check interference and the articulation of a mechanism. The program runs on DEC VAX and MicroVAX systems and on Apollo Domain systems. Single-user version, $9000; VAX or MicroVAX with four Apollo nodes, $18,000.

American Channels Inc, 1050 Waltham St, Lexington, MA 02173. Phone (617) 862-4441.

Circle No 444

B&W ENHANCEMENT

NoColor runs on the IBM PC, PC/XT, PC/AT, and compatible machines equipped with a color-graphics board and a composite monitor. This program improves the rendering of color images on a composite monochrome monitor. The user can toggle between color and B&W modes. This program is especially valuable in applications that make extensive use of color (eg, Lotus 1-2-3). The program uses 358 bytes of memory, and you can boot it via a DOS prompt or via an autoexec file. $19.95.

Personal Computer Products, 3080 Olcott Dr, B-310, Santa Clara, CA 95054. Phone (408) 988-0164.

Circle No 445

SOFTWARE MANAGER

Aide-de-Camp (ADC), a software change-control system, now runs on Prime Series 50 machines as well as on Unix and DEC VAX VMS machines. The ADC system records all changes to software in an incremental manner and provides a software audit trail. Because duplicate copies of entire files are not required, the company claims that storage savings of 50 to 90% can be achieved. By combining information management with source-code control, you can execute procedures that entail multiple changes to various software modules or programs. The database maintains information on software files, modules, or programs; version changes; external documentation; and internal structural relationships. A source-code compression facility is available as an option. Binary licenses cost $8000 for Prime office systems and $14,500 for Prime computer-room systems.

Software Maintenance and Development Systems Inc, Box 555, Concord, MA 01742. Phone (617) 369-7398.

Circle No 446

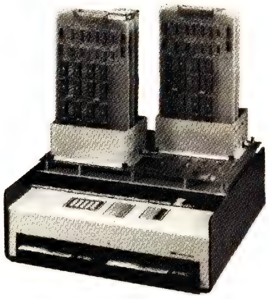
OPTICAL DATABASE

Optifile is a hardware/software package that uses multiple WORM (write once, read many) optical-disk drives to configure a multiple-write/read file-server system. The package allows as many as 32 files to be open concurrently; because the file-access protection codes have passwords, the system is suitable for use as a node in a computer network and in most applications that require removable media with a capacity as high as 1G byte per disk, and/or require as many as 56 drives in the system. An electromechanical loader/unloader (or jukebox feature) mounts and dismounts all volumes under program control. The company claims that, when used for archiving, the system can reduce storage costs to $0.65 per megabyte. The 100 version is a DECnet file server that attaches to the network via Ethernet. The 200 version is an optical-disk filing system implemented on a DEC PDP-11 microcomputer under DEC's RSX-11 operating system; application programs interface with the filing system by means of a file-access protocol using Macro-11 and Fortran calls. From $35,450.

KOM Inc, 145 Spruce St, Ottawa, Ontario, Canada K1R 6P1. Phone (613) 238-7766.

Circle No 447

AMERICA'S BEST PROGRAMMERS



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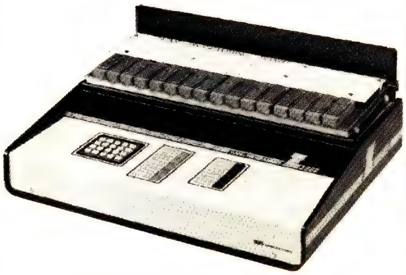

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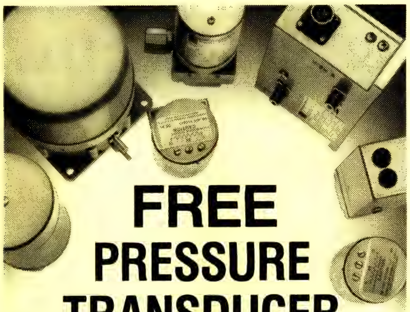

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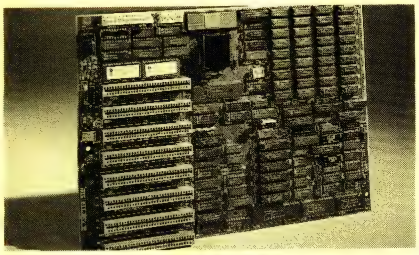

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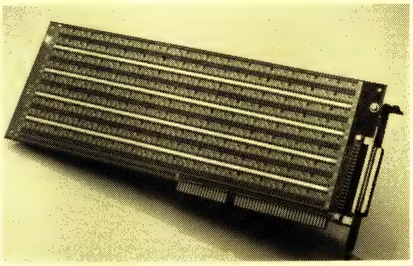

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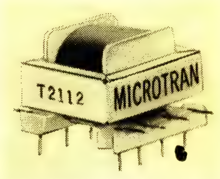

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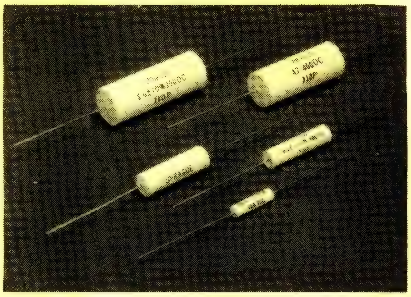

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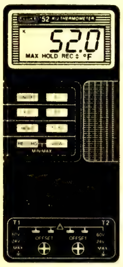

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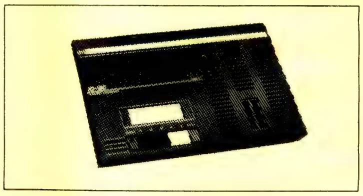

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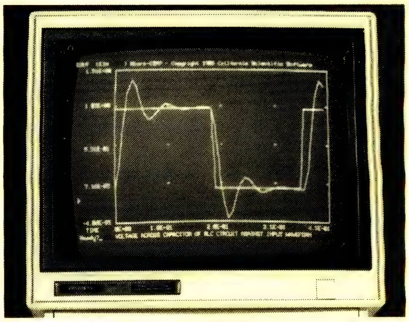

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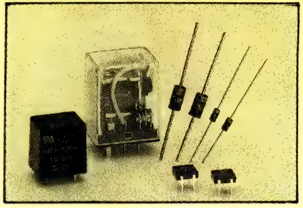

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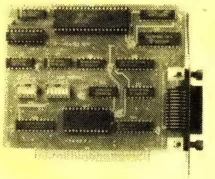

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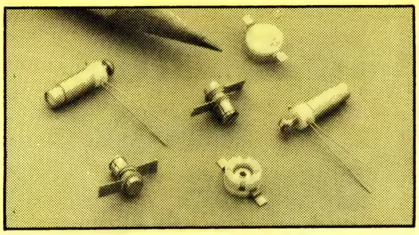

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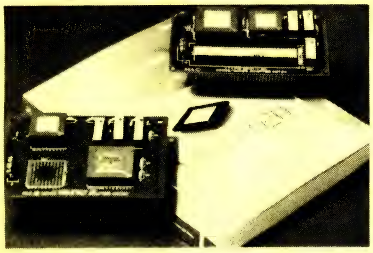

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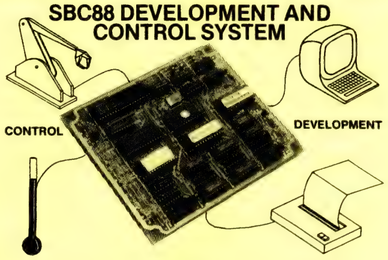

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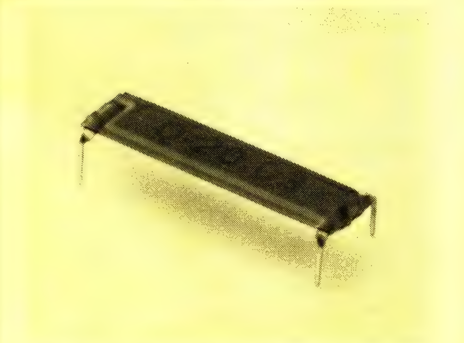

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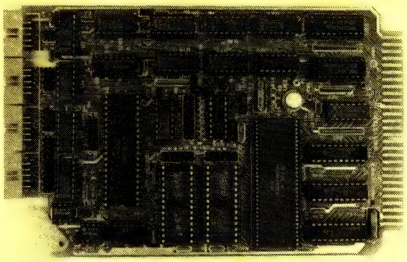

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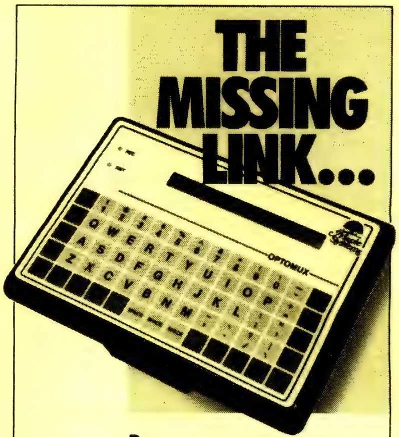

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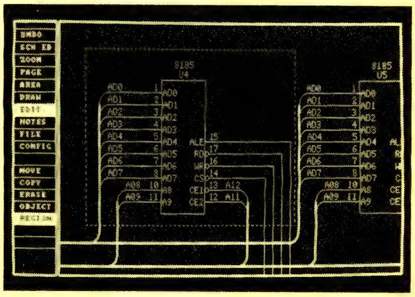

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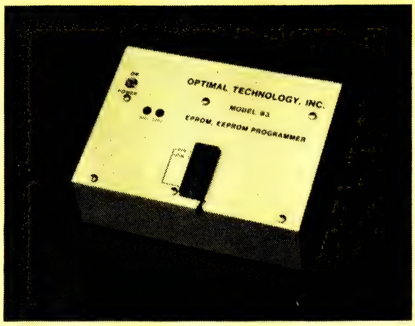

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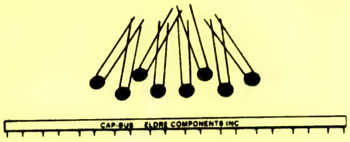

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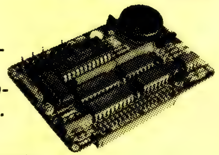

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Brochure offers specs for multiplexer

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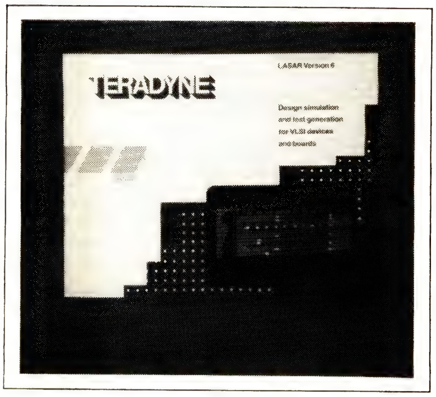
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Circuit simulator described

Highlighting the capabilities of the Lasar Version 6 simulator, this 28-pg color brochure describes how the system unites VLSI design verification and test-program generation in a common programming environment. The brochure covers use of the simulator for applications in the design and testing of VLSI circuits and pc boards. It details system features, including advanced modeling tools (and a library of device models), the ability to simulate 15 logic states, the ability to perform true worst-case timing analysis, software links that integrate Lasar with commercial CAE tools, and the ability to model test-system attributes.

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Product guide for VME Bus

This 92-pg product guide details the company's VME Bus products. Products are grouped in the following categories: development systems, CPUs, memory devices, I/O units, analog I/O and digital-signal-processing parts, display-graphics products, factory-automation products, and packaging. The comprehensive 96-pg book provides technical specs, functional descriptions, and block diagrams. Application notes are included.

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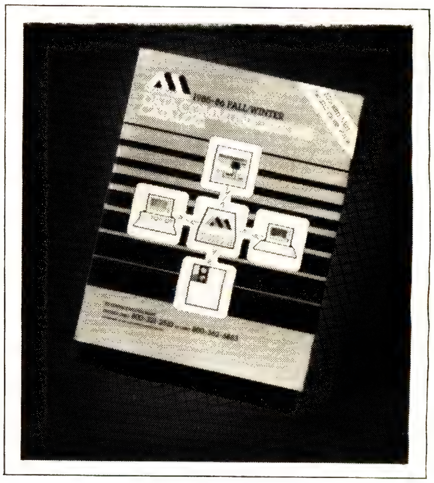

Datacomm catalog lists equipment, accessories

Featuring data and telecommunications equipment and accessories, the 144-pg *Data Communications Catalog* covers more than 250 system components and hundreds of related accessories. Modems, cables, multiplexers, test sets, and switches are covered, as are other products used to build or upgrade communications networks. The document also describes the company's services, including technical consultation, service contracts, telephone diagnosis, spare-unit guarantees for when your parts are being repaired, and board-level repairs.

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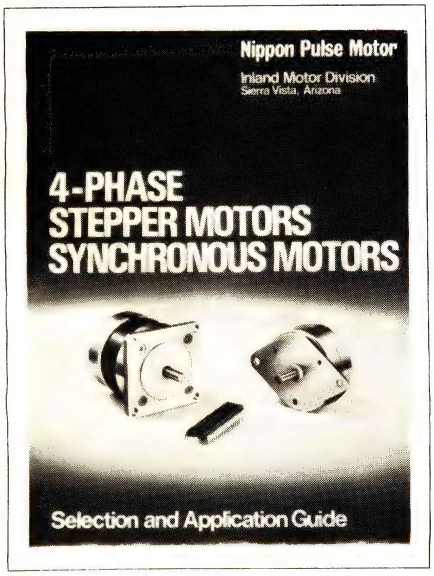
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4-PHASE STEPPER MOTORS SYNCHRONOUS MOTORS
Selection and Application Guide

Selection guide features 4-phase stepper motors

Covering three types of 4-phase stepper motors, this 24-pg selection and application guide also contains information on the company's board-type driver circuits, pulse generators, and synchronous motors. The guide includes specs, typical torque-vs-pulse-rate characteristics, and schematics for PM-, HB-, and VR-type stepper motors. The board-type drivers described are designated the PS and BCD Series. The pulse generators are those in the PLC-80K Series and the synchronous motors are designated the PTM Series. All products are produced by Nippon Pulse Motor Co.

Kollmorgen Corp, Inland Motor Div, Stepper Products Group, 4020 E Inland Rd, Sierra Vista, AZ 85635.

Circle No 430

Cables and accessories detailed

This 14-pg catalog covers cables and cable accessories. Data-cable types include RS-232C, RS-232C extended (to 500 ft), UN shielded multiconductor, and low-capacitance shielded multipair. Other cable types described are 93Ω, 75Ω, twinaxle, and plenum. Among the accessories are connectors, hardware, tools, and gender changers.

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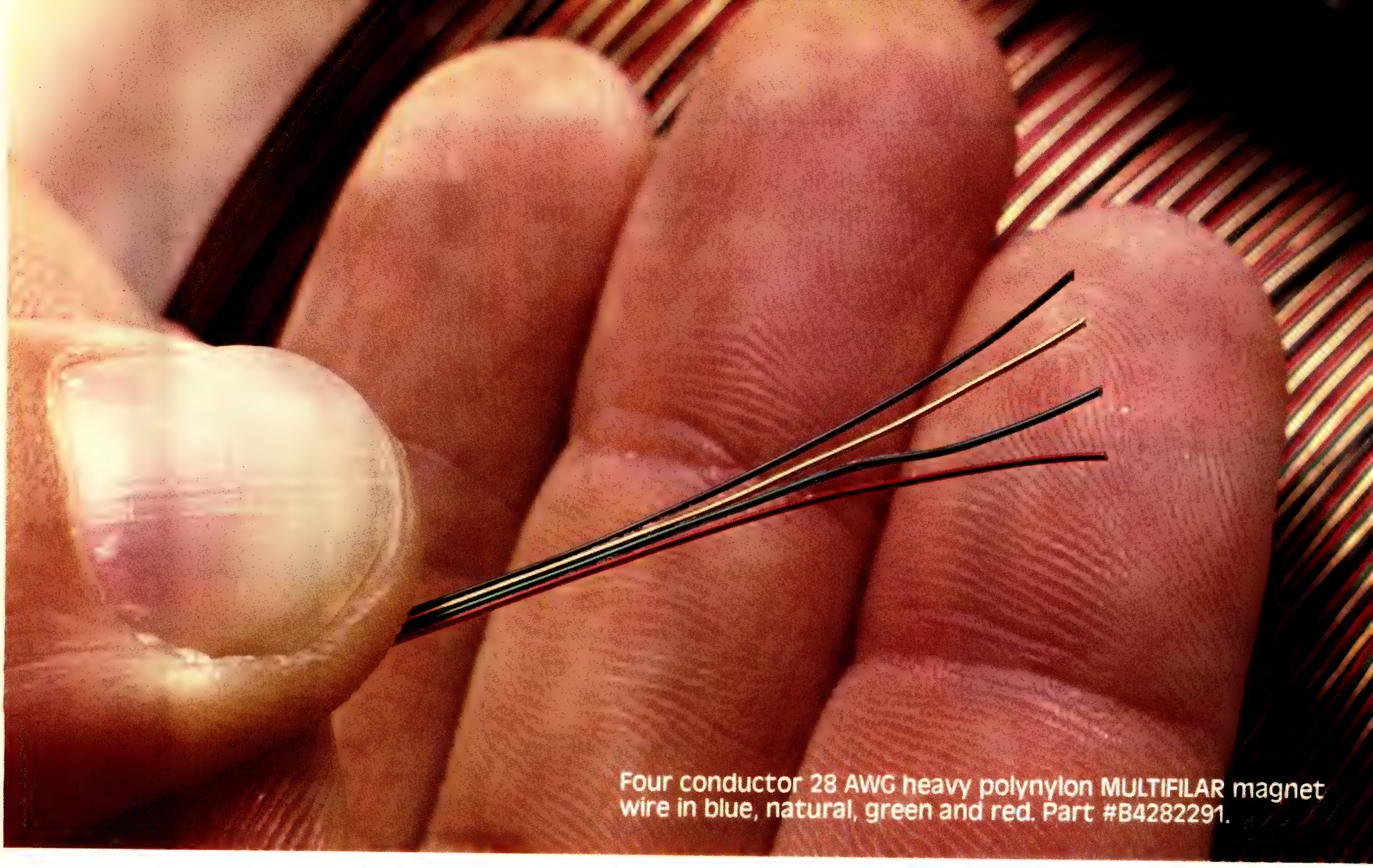

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CIRCLE NO 150

Understand the work-for-hire doctrine to obtain your software's copyright

Herbert Swartz
New York, NY

Along with the proliferation of personal computers in the engineering workplace has come an increase in the number of employees who try their hand at writing software programs. An unfortunate result of this growing occupational sideline is the tug of war between employer and employee that often erupts over ownership of the software's copyright. Unaware of the ownership provisions contained in copyright law, many employees end up losing their software copyrights to their employers.

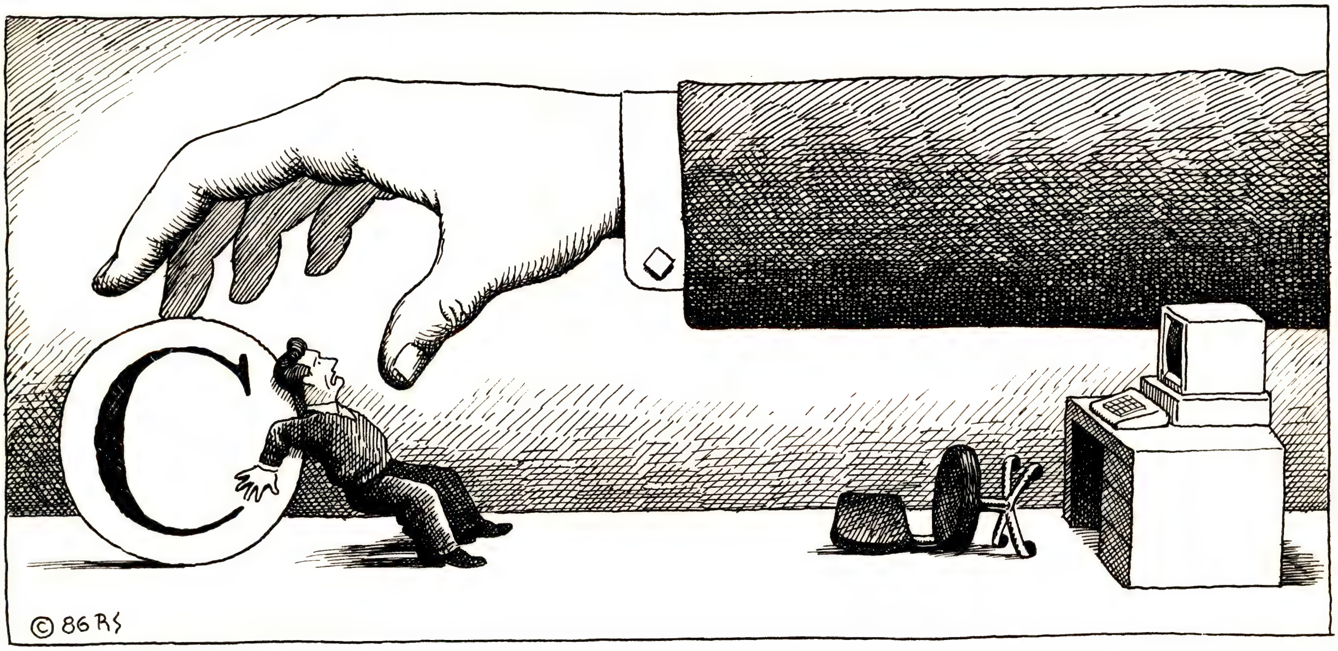
Employee-employer disputes often hinge on the "work-made-for-hire" doctrine, covered in Section 101 of the 1976 Copyright Act. The doctrine provides guidelines for settling copyright ownership in the all too common instances when an individual's employment during the development or completion of a copyrighted work raises questions about whether the work's rightful copyright owner is the employee or the employer.

Obtaining copyright ownership is critical to an individual's or a business's ability to market a product because, under the act, it is the owner of a copyright who retains control over the distribution of the material and the making of derivative works. Companies typically maintain that they own the copyright because the employee's job responsibilities contributed to his or her ability to develop the software. A second, common corporate defense is that the employee made at least partial use of the company's facilities during the project. Employees, on the other hand, often claim that the bulk of the project was completed on their own time and, therefore, they own the copyright.

What the law provides

Section 101 divides work-made-for-hire into two categories. The first category covers the work that an employee performs within the scope of his or her employment. The second category pertains to work that a person does as part of a commissioned project. Work that falls into the second category is governed by a written contract that explicitly states that the project's work is considered work-made-for-hire.

In the case of a full-time employee without some sort of contract, the main criterion for establishing copyright ownership is whether the work is within the scope of the employee's job responsibilities. To illustrate the problems that occur in these situations, attorney Geoffrey Berkin of Frerichs and Berkin (Los Angeles, CA) offers the hypothetical example of an experienced, well-paid software writer for a software development company. As a member of a team of programmers working on a major application package, John wrote a



Rob Saunders

debugging routine. In creating the routine, he developed several algorithms with broad applications that he thought could serve as the basis of a marketable debugging program. Using a company computer, John spent the next few months writing the program both during working hours and on his own time.

According to Berkin, John's work on the debugging program during off hours, although typical, might not prove an adequate defense against his employer's likely assertion that the debugging routine came about as a result of his employment. "It is not uncommon for programmers to write their own programs on their employers' computers, during working hours or in their spare time," Berkin wrote in the May 1985 issue of *The Computer Lawyer*. But whether or not John's efforts constitute work-made-for-hire, he elaborated, "depends on a number of factors—which may ultimately be determined at the end of expensive and time-consuming litigation during which the rights of the programs are tied up."

An employee can benefit from a written agreement that establishes ownership of any works the employee creates, but unfortunately, employers and employees do not always enter into such contracts. Even in instances in which an employment contract exists, the document doesn't always adequately address the question of copyright ownership. In these cases, employers and employees often find themselves haggling over whether the contract's stipulations satisfy the requirements of the second category of the work-made-for-hire statute.

Even if the relationship between an employer and an independent third party is defined by a written contract, disagreement over copyright ownership can occur if the terms of the agreement are unclear. Usually, the two parties find themselves at odds over whether the contractor was acting as an employee and, therefore, whether his or her work fell within the scope of employment.

An employer can take several routes to try to prove that the contractor was actually working as an employee and, therefore, the work done by the contractor was considered to be within the scope of employment. "Parties commissioning software may be able to successfully claim that the outside software developer is an 'employee' where . . . the commissioning party literally 'looks over the shoulder' of the programmer, and closely directs the work as it progresses," attorney Lance Rose of Brown, Raysman & Millstein (New York, NY) wrote in the wake of a recent court decision (Aldon Accessories vs Spiegel, 1984). In that case, a New York federal appeals court held that an independent contractor was actually an employee acting within the scope of employment.

In addition, the commissioning employer can attempt to establish supervision beforehand by reviewing and directing the software's development on a regular basis. It can also require the contractor to work on the project only during normal working hours on the company's premises and using only its facilities.

To date, computer law has had no definitive case in the area of scope of employment. Nevertheless, the federal district court in New York decided a copyright infringement case (West vs City of New York, February 1985) that may shed light on this aspect of computer law. In the New York case, a city employee had sued the city for publishing charts and articles that, the employee said, she had prepared on her own time. In finding that the copyright belonged with the city, the judge gave a broad interpretation of scope of employment. The New York case holds some insight into how the courts may view scope-of-employment boundaries, but there is no guarantee that they will decide computer-law cases similarly. The writing of computer programs is a special category. Everyone is aware that much of the work is done after working hours. It is unknown how judges will respond to these cases.

Taking preventive measures

While they wait for the wheels of the judicial system to turn, employees and employers can begin to help themselves. Lacking a solid definition of scope of employment, the two parties can start to remedy the situation by drafting a contract that tailors the scope of employment to the specific situation at hand. Attorney Berkin cautions employers against drafting contracts that define scope of employment so broadly (including even employees' activities outside of work) as to render the contracts ineffective. Simply writing, for example, that "all products of Employee's intellect, skill, and ability are deemed to have been created within the scope of Employee's employment" is an invitation to a lawsuit. A court would probably consider such language too all-encompassing and unreasonable.

"It would likely be seen as attempting to circumvent the definitional limitations in the statute and to change the copyright law by contract," Berkin explains. "Additionally, it would likely be seen as overreaching on the part of an employer in an attempt to capture ownership of intellectual property to which the employer ought not to have claim, such as, for example, a video game written by an employee at home on her Commodore 64." Berkin offers the advice, however, that a broad definition of scope of employment would be honored if business needs or circumstances justified it.

Agreements between employers and third parties are less complicated than contracts between employers and employees. When a company hires an independent contractor, says attorney Stephen Hollman of Gullixson, Hollman & McCroskey (Palo Alto, CA), the written agreement must clearly state that the software developed is to be considered a work-made-for-hire. If the contract does not explicitly make this statement, the project isn't considered a work-made-for-hire and the independent contractor is considered the owner of the software's copyright. According to the 1976 act, the author of a creative "expression"—in this case the software—owns the copyright to the work.

Joint ownership isn't usually an ideal situation; suddenly two parties who had no intention of entering into a partnership are partners.

Thus, says Hollman, most corporate attorneys are careful to insert a clause in an independent contractor's agreement that states that the software is a work-made-for-hire, that the person paying for the software is considered to be its author, and that the independent contractor assigns all of his rights to and interest in any copyright ownership of the software to the person paying for the work.

Consider another option

If an employee's or a third party's contract doesn't contain a work-made-for-hire clause, or if a third party doesn't have a contract at all, the 1976 Copyright Act contains an assignment section that also addresses copyright ownership. Copyright assignees should be aware that acquisition through this route requires registration with the Copyright Office in Washington, DC. For authors, copyright ownership exists upon creation; no notification with the Copyright Office is necessary. And because work-made-for-hire is akin to creation, no notification is necessary in these instances, either. Assignment is different: An assignee has no rights in the first place. An assignee must register with the Copyright Office in order to give notice that he or she is the true owner of the copyright. An assignee who does not register copyright ownership is barred from filing suit against an unwitting infringer.

Whether a person acquires copyright ownership through the Copyright Act's work-made-for-hire provision or the assignment section makes little difference in practical terms. The duration of a copyright in a work-made-for-hire is 75 years, whereas an assigned copyright endures for the life of the original creator plus 50 years. Berkin says that, in the context of software, these differences are slight. "Given the rate of advance in the software arts, these provisions seem unlikely to terrorize any computer executives," Berkin notes.

Share the software's copyright

A last possible option for attaining some sort of control over software paid for by an employer is joint ownership. The 1976 Copyright Act does recognize joint ownership. In the case of software, however, the assertion of joint ownership is only possible if a person or company who has paid for the work has assisted in its design and creation. According to the act, joint work on a project "is work prepared by two or more authors with the intention that their contributions be merged into inseparable or interdependent parts of a unitary whole." Attorney Hollman says, "A good example of a joint work would be the programming of specific modules by an independent contractor, and the design of the overall work and programming of other modules by the person paying for the software."

"If the commissioning party actually writes some of the code together with the outside developer," Lance Rose adds, "it is likely they will be considered joint authors of the software." But what if all of the code is written by the contractor? How much and what kind of contribution must the commissioning party make for it to be considered a coauthor? "An employer that determines the functions to be performed by the software, the manner in which the data is stored and changed, the intention of software functions, and features of the user interface such as monitor format and response time, might well qualify as a contributing designer and coauthor of the program," Rose advises, "despite not having personally written a line of code."

Joint ownership, however, isn't usually an ideal situation. Suddenly two parties who had no intention of entering into a partnership are partners. Although half a copyright may be better than no copyright, it is not as good as full copyright. You can enhance your chances for attaining full copyright by consulting a lawyer and paying proper attention to the possibilities set forth in the second category of the work-made-for-hire doctrine. **EDN**

Author's biography

Herbert Swartz is a freelance writer. He holds a law degree from Harvard Law School (Cambridge, MA). He practiced law for 10 years and now writes on computer law for several publications.

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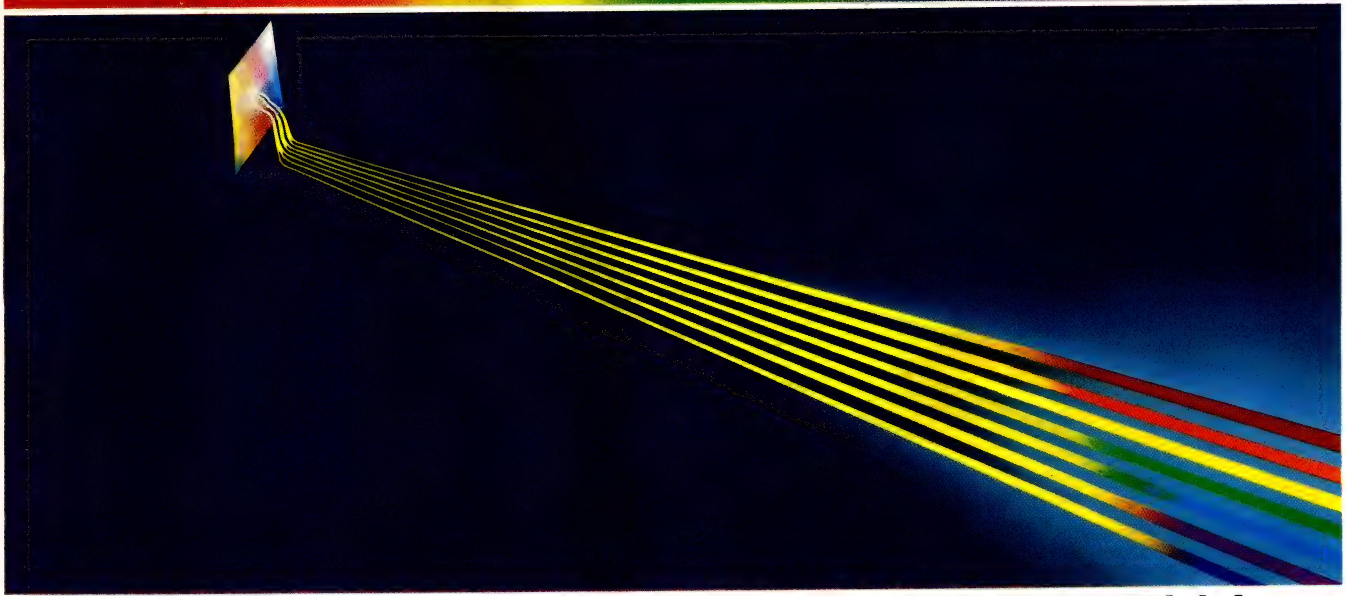

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Digital VLSI Engineers—BSEE/MSEE with a minimum of 4-6 years experience in semicustom VLSI design, fast CMOS and ECL technology. Expertise with Daisy CAD sytems, custom VLSI and 50 MHz CMOS desired.

Digital Signal Processing Engineer—BSEE/MSEE with 4-8 years experience in DSP, time domain equalizers, 256 QAM modulation, multi-level modulation, passive filters and FIR digital filters required.

High Speed Digital Engineers—BSEE with 2-4 years experience in high speed digital design using ECL logic design, multiplex circuits, demultiplex circuits required. Knowledge of impediance matching and load termination desirable. Prior analog circuit experience very helpful. Expertise in LSI, SPICE, CAD, helpful. Position involves design of digital multiplex/demultiplex modules for high capacity lightwave transmission equipment.

DIGITAL ACCESS CROSS-CONNECT DESIGNERS

DACS Hardware Engineers—BSEE/MSEE with minimum 3-8 years of experience in the design of electronic cross-connect systems with DS1 to DS3 termination hierarchies. Experience in high/low frequency VLSI custom circuit design, digital signal processing, surface mount technology and CAD/CAM development equipment required.

DACS Software Engineers—BSEE/MSEE with 3-10 years experience in software development of electronic cross-connect systems with DS1 to DS3 termination hierarchies. Experience requires UNIX, C Programming and 68000 microprocessor applications. Software tasks include development of operating systems, data base management, maintenance and switch control, provisioning and remote telemetry interfaces.

SURFACE MOUNT TECHNOLOGY

Surface Mount Device Engineer—BSEE/ME with a minimum of 3-5 years of processing engineering experience using surface mounted devices in an automated microelectronics manufacturing environment. Knowledge of screening processes, pick and place machines, other component robots, infrared and vapor phase reflow, visual inspection systems and automated cleaning systems desired. Should have experience with processing of double-sided high density boards, mixed technology lines and solder/reflow methods desired.

SMT Autotest Engineer—BSEE with 2-6 years experience in SMT in-circuit autotest on high speed circuits. Knowledge of HP equipment, BASIC, PASCAL and test fixturing required.

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You owe it to yourself to find out what Rockwell may have to offer you. Begin by sending your resume in confidence to: **Kevin L. Weiss, Professional Staffing, Rockwell International, Collins Transmission Systems Division, M/S 401-152, #8457, P.O. Box 10462, Dallas, Texas 75207.** U.S. Citizenship Required. Equal Opportunity Employer M/F.

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Sr. / Software Engineer(s), Gateway Product Development

As an experienced designer-developer of industrial LAN software ("C" programming language) with a BSCE, BSCS or BSEE degree, you're ready to design and develop user-configurable LAN gateway products. This software technology will enable users to interface their industrial devices to standard LANs — ISO / OSI, MAP, etc. Using state-of-the-art compiler "tools," you'll design / code at the system, subsystem and module levels, and take the product from conceptualization through product support.

Software Engineer, Advanced Communications Technology

You'll be using your BSCE, BSCS or BSEE degree and 2-4 years experience in the design and development of industrial LAN software, using the "C" programming language. Your responsibilities will include: research, design, development and testing of Industrial Standard LAN software, including LAN protocol, real-time subnetwork and local station management software, all based on marketing requirements.

Hardware Engineer, Gateway Product Development

You have a BSCE / BSEE or equivalent degree and 2-4 years of experience in industrial LAN hardware design and development. Based on Marketing requirements, you will design Gateway Products hardware at the system, subsystem and module level. Includes system components, specific subnetwork, target device interface module hardware, 32-bit microprocessor-based processor modules, generic part and I / O interfaces, and associated support circuitry.

Hardware Engineer, ISO / MAP LAN

You will design and develop ISO / MAP LAN product hardware and provide technical support for such ISO / MAP products as RF modem modules, 32-bit microprocessors and peripherals, LAN specific LSO or VLSI bus interfaces and surface mounted components. You will also generate all required design documentation. You're BSCE or BSEE (MSEE preferred) degreed and have 2-4 years experience in the design and development of industrial LAN hardware.

Supervisor, LAN Product Standards & Projects

You would be our standards specialist — an internal resource providing guidance in product development phases to assure compliance with IEEE 802, EIA, ISO and the MAP standards. You would coordinate the certification testing (protocol validation) program and field tests, while supporting marketing activities. Another interesting aspect: analyzing and projecting the direction of developing MAP standards…and then planning product specification / positioning strategies accordingly. Requirements include: BS in engineering or computer science (or equivalent) with 5+ years of experience in digital electronic control systems (industrial applications / marketing / product management). An educational focus on control systems / data communications would be a plus.

LAN Application Engineer(s)

Reporting to the Supervisor, Standards & Projects, you would have responsibility for project coordination and application engineering / consulting as they relate to marketing of our MAP-compatible LAN products. For example, you could develop the application engineering or certification testing, field tests, customer demonstrations, trade show exhibits, etc.…while providing field support / customer interface during testing or start-up. Requires a BS in engineering or computer science (or equivalent); engineering / application experience in data communications / computer systems / industrial automation equipment; and knowledge of ISO protocols.

Supervisor, OEM Marketing

In this high-visibility position you would be responsible for key elements of MAP-compatible OEM product management — OEM agreements, product specification / documentation, and customer liaison. Responsibilities would include: establishing the functional requirements of new products…planning for enhancements…performing competitive analyses…and developing product positioning strategies. You should bring to the position a BS in engineering or computer science (or equivalent) and 5+ years of experience in digital electronic control systems (industrial applications / marketing / product management). An educational focus on control systems / data communications would be a plus.

An excellent salary-benefits package, including dental / life / health insurance plans and third party relocation assistance is offered. Discover the advantages of Allen-Bradley…and Ann Arbor. Call me at (313) 973-1500…or send your resume to:

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We are seeking Software Engineers to develop 3270 micro-to-mainframe communications systems on IBM PC's and compatibles. Projected areas of development include:

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Graphics
SNA/LU 6-2
Distributed Function Terminal Technology (DFT)

You should have a BSCS, BSEE or equivalent plus two years experience in design and implementation of software on an IBM PC or compatibles. Experience with PC-DOS, "C," and/or 8086 assembler required; exposure to 3270 mainframe data communications (SNA, BSC, DFT) preferred. An ability to perform self-directed work is a plus.

At DCA we offer bonuses based upon performance, competitive salaries and comprehensive benefits. If you are interested in joining a leader in the data communications industry, respond by sending your resume and/or letter of interest to: **Digital Communications Associates, Inc., 1000 Alderman Drive, Dept. 929, Alpharetta, Georgia 30201.** Equal Opportunity Employer.

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ERIM REPORT #4

The Science of Range-Doppler Imaging

Fundamental range-Doppler radar imaging methods developed at ERIM are providing new capabilities in a variety of applications.

Range-Doppler Imaging

Fine Resolution microwave or laser images of objects which are rotating with respect to the radar system can be formed using the principles of range-Doppler imaging. Range resolution for such a system is provided by ranging with wideband waveforms subjected to pulse compression to accurately measure distance to the scatterers of interest. Cross-range, or azimuth, resolution is provided by performing Doppler-frequency spectral analysis (FFT) within range bins. Signals with higher Doppler frequency content are associated with scatterers of greater line-of-sight velocity which in turn implies increasing cross-range offset from object center. Display of the range bins and Doppler-frequency cells within range bins in a rectilinear grid results in a reflectivity image of the rotating object or scene.

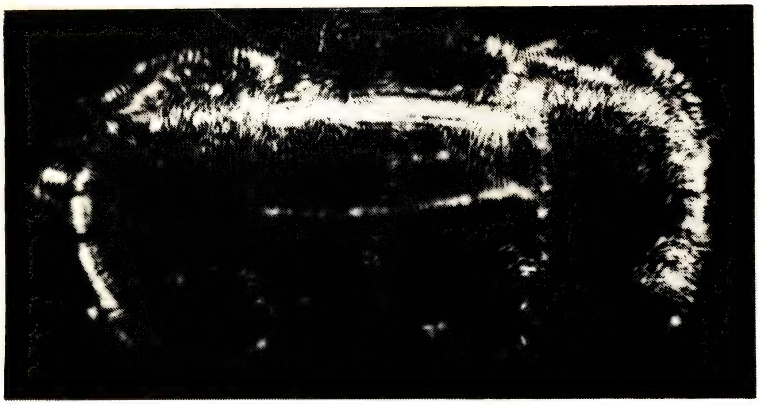
With this approach, finer azimuth resolution is obtained by performing the Doppler spectral analysis over increasing time intervals. However, as one strives for finer resolution the integration time can become so long that individual scatterers begin to move through the image resolution cells that one is attempting to form. In such a case the resultant image quality actually degrades with increased integration time.

Polar-Format Algorithm

A number of image-formation algorithms have been formulated to compensate for the effects of motion through cells during the integration period. The Polar-Format Algorithm, developed at ERIM for use with our ground-based and airborne imaging radar systems, has become widely noted as an extremely powerful, yet elegantly simple and efficient method for overcoming these previous limits of imaging capability. The images below show a Volkswagon and its associated microwave range-Doppler image processed using the Polar-Format algorithm. This image was produced using the ERIM ground-based, range-Doppler imaging facility.

Applications

Fine-resolution range-Doppler imaging is applicable to a number of situations, including space object imaging (SOI), Inverse Synthetic Aperture Radar (ISAR), and Spotlight-mode SAR for airborne imaging of ground scenes. In principle, the approach is suited to both optical and radar wavelengths, Also, the theory has been extended to allow for three-dimensional imaging of objects given suitable signal collection configurations.



The Environmental Research Institute of Michigan (ERIM) is a scientific research institute that performs contract research services for a variety of sponsors. Our sponsors include government organizations, industry, and universities. Research at ERIM focuses upon remote sensing systems, devices, and techniques that span the electromagnetic spectrum. Within this broad research area, staff members employ their knowledge of modern electronics, optics, computer science, and infrared and microwave physics.

Career Opportunities

ERIM's technical divisions have research and management positions available in Ann Arbor, MI, Washington, DC, and Los Angeles, CA. Positions are available at several levels in the following areas:

- **Radar System Engineering and Analysis**
- **Signal and Image Processing**
- **Microwave Scattering and Measurement Engineering**
- **Diffractive Optics**
- **E-O/IR System Design and Analysis**
- **Infrared Phenomenology**
- **Computer Vision**
- **Optical Computer Systems**
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All positions require a BS, MS, or PhD in engineering, physics, mathematics, or statistics, along with appropriate work experience. Salary and benefits are highly competitive.

For details, telephone (313) 994-1200, ext. 2260. Or send your resume to Personnel Administrator, Dept. MA, ERIM, P.O. Box 8618, Ann Arbor, MI 48107-8618.

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ANNOUNCING ANOTHER BONUS FOR YOU FROM EDN:

EDN Product News

TECHNOLOGY UPDATE

LCD-driver/ controller ICs offer versatility in configuration and function

By Ed Teja,

INSIDE

TECHNOLOGY UPDATE

Thermoplastics enhance design options

Every two weeks, *EDN* helps you do your design jobs more efficiently with editorial focused on the applications of new products and technology. Now, once a month *EDN Product News* will augment *EDN*, helping you select new products. In a tabloid format, *EDN Product News* will cover in greater depth the components, equipment, and systems you need to solve design problems.

Your copy of *EDN Product News* will be arriving soon. When it does, you'll see that *EDN Product News* provides the freshest, most detailed information available on new products and new-product developments.

Premiering April 10, 1986

EDN Databank

Professional Profile

Announcing a new placement service for professional engineers!

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Home Address: ______

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Home Phone (include area code): ______

PRESENT OR MOST RECENT EMPLOYER

Parent Company ______

Your division or subsidiary: ______

Location (City, State) ______

Business Phone if O.K. to use: ______

EDUCATION

Degrees (List)	Major Field	GPA	Year Degree Earned	College or University

POSITION DESIRED

______

EXPERIENCE

Present or Most Recent Position From: To: Title: ______

Duties and Accomplishments: Industry of Current Employer: ______

______

______

______

Reason for Change: ______

PREVIOUS POSITION:

Job Title: ______

Employer: ______ From: ______ To: ______ City: ______ State: ______

Division: ______ Type of Industry: ______ Salary: ______

Duties and Accomplishments: ______

COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation

Date Available	I Will Travel ☐ Light ☐ Moderate ☐ Heavy	☐ I own my home. How long? ______ I rent my home/apt. ☐
☐ Employed ☐ Self-Employed ☐ Unemployed	☐ Married ☐ Single	Height______ Weight______

Level of Security Clearance	☐ U.S. Citizen	☐ Non-U.S. Citizen	My identity may be released to: ☐ Any employer ☐ All but present employer

☐ WILL RELOCATE ☐ WILL NOT RELOCATE ☐ OTHER ______

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BOOK REVIEW

Two guides to FFT algorithms and techniques

***DFT/FFT and Convolution Algorithms: Theory and Implementation,** by C S Burrus and T W Parks. 232 pgs; $22.50 (softcover); John Wiley & Sons, New York, NY, 1985.*
***The FFT, Fundamentals and Concepts,** by Robert W Ramirez. 178 pgs; $28.95 (hardcover); Prentice-Hall Inc, Englewood Cliffs, NJ, 1985.*

Unlike most technical authors who discuss the Fourier transform and the fast Fourier transform (FFT) in strictly mathematical terms, C S Burrus, T W Parks, and Robert Ramirez provide refreshing approaches. The first chapter of *DFT/FFT and Convolution Algorithms* reviews Fourier integrals and transformations, as well as frequency-domain signals, discrete-time signals, and the discrete Fourier transform (DFT), in a mercifully brief 19 pages. If you're familiar with those topics, skip to Chapter 2, which contains information about using and calculating results with the DFT. Instead of asking you to move on your own from integral equations through the algorithm process and finally to working computer programs, the authors provide Fortran programs in the text. In this chapter, you'll find programs that range from the radix-2 Cooley-Tukey routine to the prime-factor, or Winograd, routine.

The book's third chapter quickly describes discrete-time convolution. Although the mathematics is sufficient to introduce convolution and show you how to apply it, once again the emphasis is on practical applications. The last chapter provides the most useful information: 20 DFT programs and two test programs—all written in Fortran. The Fortran steps aren't difficult to translate into Basic or Pascal. For example, in a Basic program, substitute FOR-NEXT loops for the DO-CONTINUE loops in the Fortran listings. You must also translate Fortran's comparison operations that use notations such as EQ (equal to) and GT (greater than) into equivalent IF-THEN operations in Basic.

Besides the Fortran programs, the authors also list nine assembly-language programs written for the Texas Instruments TMS32010 digital-signal-processor chip. The programs include six FFT routines, a DFT and a convolution routine, and a second-order Goertzel DFT algorithm. If you need more information about Fourier transforms, consult the many references that the authors thoughtfully list in the first three chapters.

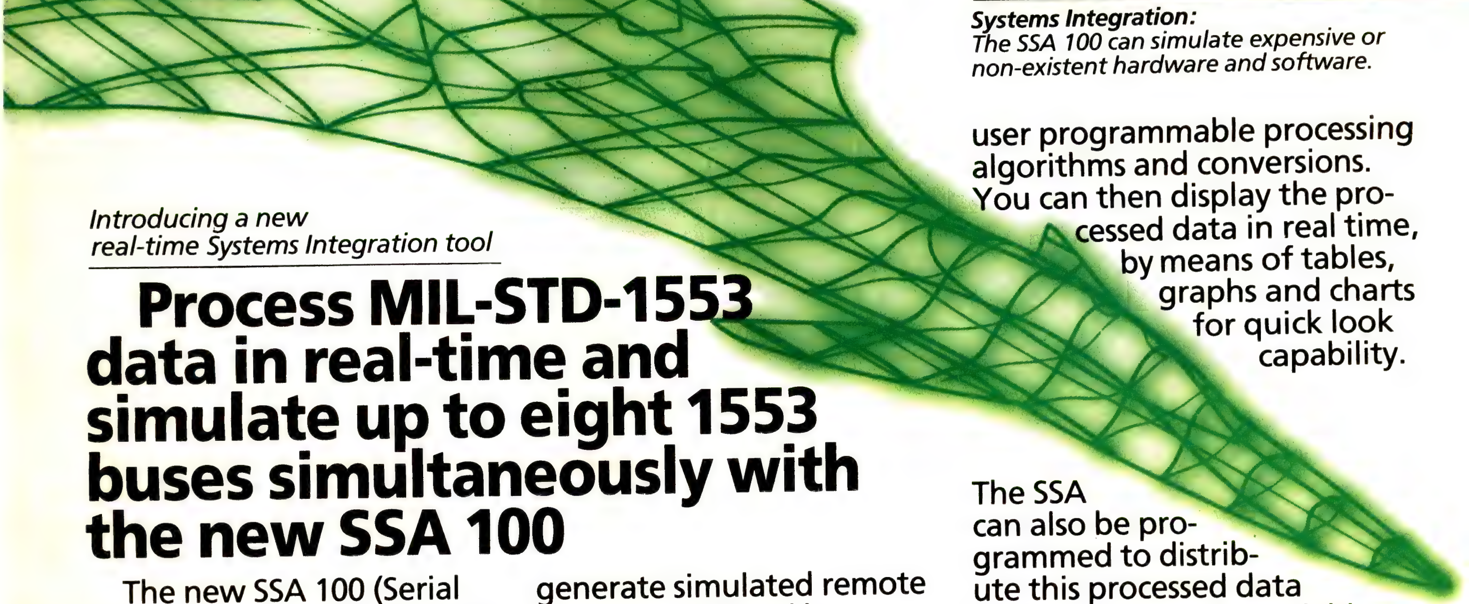
If you're not quite ready to jump into FFT algorithms but still want an introduction to FFTs, Robert Ramirez's book is an excellent starting point. In the first three chapters, the author provides clear descriptions of the time and frequency domains and how you pass information between them. Whereas many text and reference books provide mathematical derivations that illustrate Fourier integrals and transforms, Ramirez uses rectangular amplitude-vs-time and -frequency plots instead.

The second section of the book describes digital Fourier analysis starting with a description of the discrete- and fast-Fourier transforms and how they operate. The section includes a 20-line Basic program that computes a 32-point DFT and provides you with an understanding of how the DFT algorithm processes signal information.

Additional chapters in the second section describe how to interpret the FFT process's results. Like any powerful tool, you must consider carefully how the FFT treats data so you can prepare the raw information for proper processing. Ramirez points out the effects of A/D conversion and describes signal windows as well as leakage, aliasing, and other sources of errors. Signal plots and scope-screen photographs graphically illustrate how errors affect processing results. You'll also read about techniques you can apply to improve FFT-processing results, as well as typical FFT-applications and signal-correlation techniques.

The last—and shortest—part of Ramirez's book briefly describes the mathematics of the FFT and includes a radix-2 FFT program written in Basic. The book does an excellent job of introducing FFT signal processing; however, the math section doesn't include all of the derivations and equations you'll need to develop your own FFT algorithms. Yet *The FFT, Fundamentals and Concepts* provides an excellent introduction and a practical guide to the Fourier transform. And if you're using a small computer for FFT operations, then *DFT/FFT and Convolution Algorithms* should be part of your engineering library.

—Jon Titus



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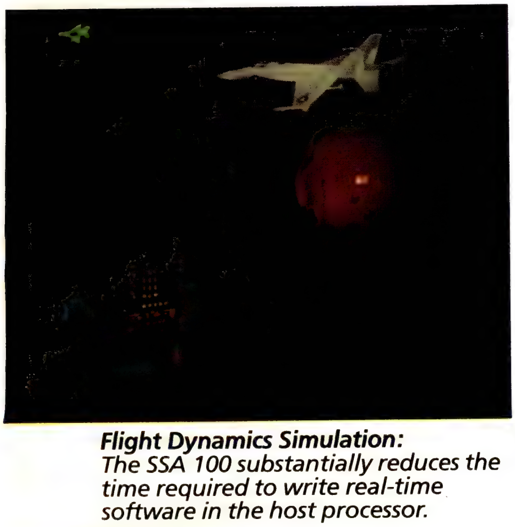

Flight Dynamics Simulation:
The SSA 100 substantially reduces the time required to write real-time software in the host processor.

In addition to monitoring bus activity, you can simulate dynamic-data updates in real time. That means that if you are developing a new product that is going to work on a MIL-STD-1553 bus, you can generate simulated remote terminals (RT) and bus controller (BC) responses, and do it in real time on as many as eight MIL-STD-1553 dual-redundant buses simultaneously.

The SSA's modular system architecture offers many optional features that make it easier for you to integrate and test MIL-STD-1553 products. Some options include IRIG time code generation and correlation capability, analog/discrete input and output capability, automatic error and limit checking, as well as a bi-directional DMA channel to your host computer. The DMA allows the SSA 100 to function as a pre-processing element within a system.

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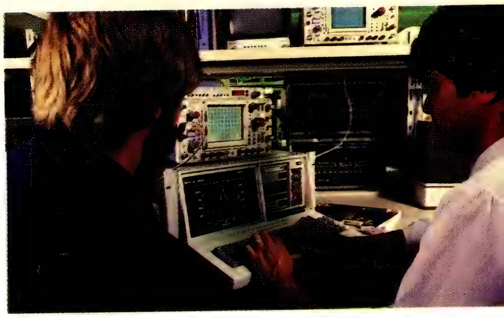

Systems Integration:
The SSA 100 can simulate expensive or non-existent hardware and software.

The SSA can also be programmed to distribute this processed data through the many available interfaces such as IEEE 488, RS 232, analog/digital outputs, and to mass storage devices including digital tape and disk controllers.

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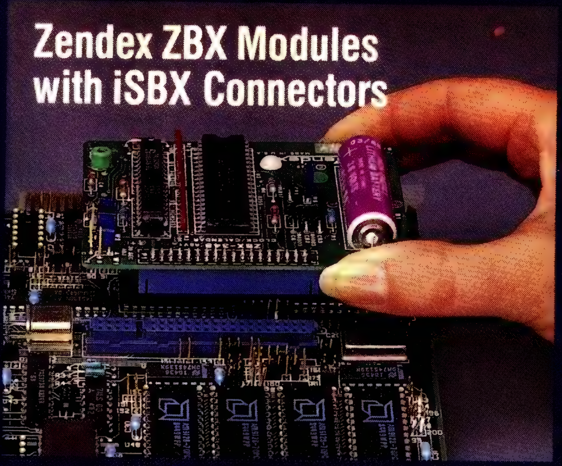

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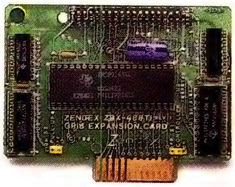
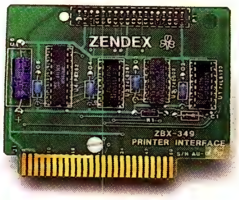


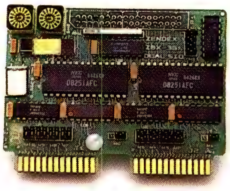
ZBX 488
IEEE-488 Interface Module

- Complete intelligent interface to IEEE-488 1978 standard.
- Standard protocol handled automatically in Talker, Listener or controller operations through a TI TMS-9914 GPIB adaptor chip.
- RMX-86 drivers available.



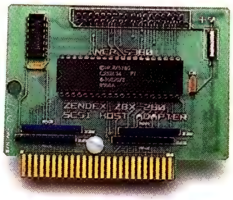
ZBX 349
Centronics Printer Interface Module

- Provides direct interface to Centronics compatible parallel printers through the SBX bus.
- Includes an eight foot interface cable which plugs into a 50 pin edge connector on the board.
- Generates data strobe and latches data for use by printer.



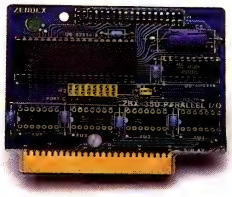
ZBX 361
Dual Serial I/O Expansion Module

- Provides two RS 232C serial communications channels using two 8251A programmable USARTs.
- Two 26 pin edge connectors for mating with standard 3M type connectors.
- Switch selectable dual baud rate clock with 16 variable rates from 50–19.2K baud.



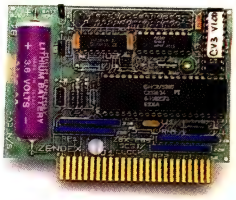
ZBX 280
SCSI Interface Module

- Supports floppy disk drives, Winchester drives and streaming tape drives.
- Supports I/O and DMA modes with DMA transfers up to 1.5M bytes/sec.
- Utilizes NCR 5380 chip which provides complete control of the SCSI bus and full handshake signals.
- RMX-86 drivers available.



ZBX 350
Parallel I/O Expansion Module

- Provides 24 programmable I/O lines configured as three 8-bit ports through one 8255 programmable peripheral interface.
- One of three modes: basic I/O, strobed I/O or bidirectional bus interface to external buses.
- Four 14 pin sockets.

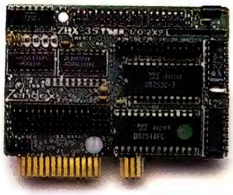


ZBX 288
SCSI with Clock/Calendar

- Full ANSI X379.2 interface.
- Utilizes NCR 5380 chip.
- Same clock/calendar features as ZBX 348.

ZBX 348
Clock/Calendar Module

- Provides seconds, minutes, hours, day, date, month and year to any host single board computer.
- Lithium battery provides power for five years.
- Accurate to within ± 5 seconds per month.
- RMX-86 utilities available.



ZBX 351
Serial I/O Expansion Module

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LOOKING AHEAD

EDITED BY GEORGE STUBBS

Falling prices spur sales of copier/printer systems

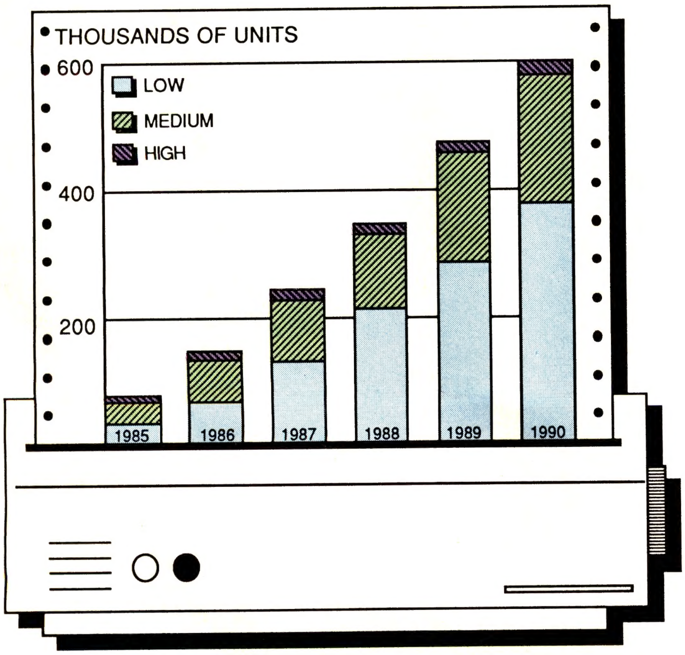
A decline in prices will be a major factor in the growth of the market for intelligent copier/printer equipment, reports the market-research company, Venture Development Corp (VDC) (Natick, MA). Price cutting will gouge the profit margins of large and small companies that maneuver to maintain or improve market share. Even as sales soar—VDC predicts shipments of 600,000 units by 1990—only a few vendors will see substantial profits.

Intelligent copier/printers accept digital inputs from such equipment as graphics scanners and word and data processors, and then produce documents in bulk. These documents can merge text and graphics and handle multiple type styles and fonts. VDC distinguishes between low-, medium-, and high-volume copier/printers. Low-volume units produce less than 20,000 pages monthly, medium-volume between 20,000 and 250,000 pages, and high-volume units more than 250,000 pages per month.

The price war will be hottest at the low end, where cost clearly plays a more important part in buying decisions. New technology that will reduce manufacturing costs and improve reliability will only complicate vendors' strategies, says VDC. What's more, the Japanese, who were once content simply to build print engines, may soon be ready to enter the market at the low end.

Growth at the high end will be slower. High-volume copier/printers cost more and appeal to customers who specifically need to produce documents in large quantities, so the volatility of prices characteristic of the other market segments will be less of a factor. The growth of medium-volume units is expected to increase between 1985 and 1990 as prices start to come down and as customers find that they're attracted to the systems' printing speeds and computer compatibility.

SHIPMENTS OF INTELLIGENT COPIER/PRINTERS



(SOURCE: VENTURE DEVELOPMENT CORP)

Comm ICs to lead the way in development of GaAs

Gallium arsenide ICs—with their promise of higher speeds and ability to emit light—will in the near future make their presence felt most keenly in the communications segment of the electronics industry. According to Electronic Trend Publications (Cupertino, CA), the total GaAs-IC market will grow from 1985's $60 million to $1.8 billion in 1990. During that time, the share of GaAs ICs devoted to communications-related tasks will grow from 12 to 35%.

The combination of signal-processing and light-emitting functions in optoelectronic communications ICs is expected to drive the growth of GaAs use. Recent progress in digital-signal-processing circuits based on GaAs substrates has opened up a range of possibilities for integrated optoelectronic devices, says Dr Robert N Castellano, who has worked in wafer fabrication at Bell Laboratories and Stanford University. These integrated optoelectronic devices include light transmitters and receivers with on-chip computational circuitry.

The initial applications for the GaAs optoelectronic ICs will be in the large, fiber-optic communications trunks currently being installed by the major common carriers. As GaAs technology overcomes its cost and technological barriers, the devices will find application in local-area networks and other systems that call for the transmission of large amounts of data. Eventually, the optical links could replace copper connections between chips and subassemblies of a system.

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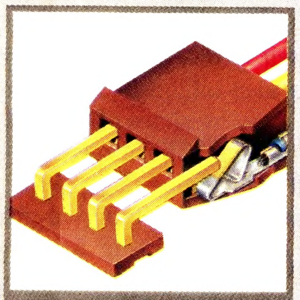

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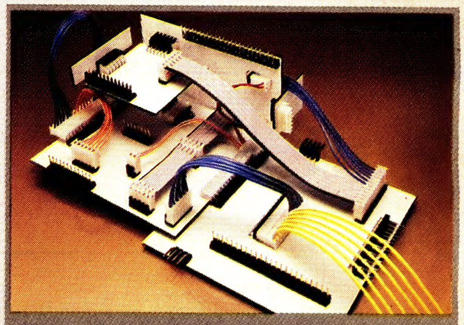

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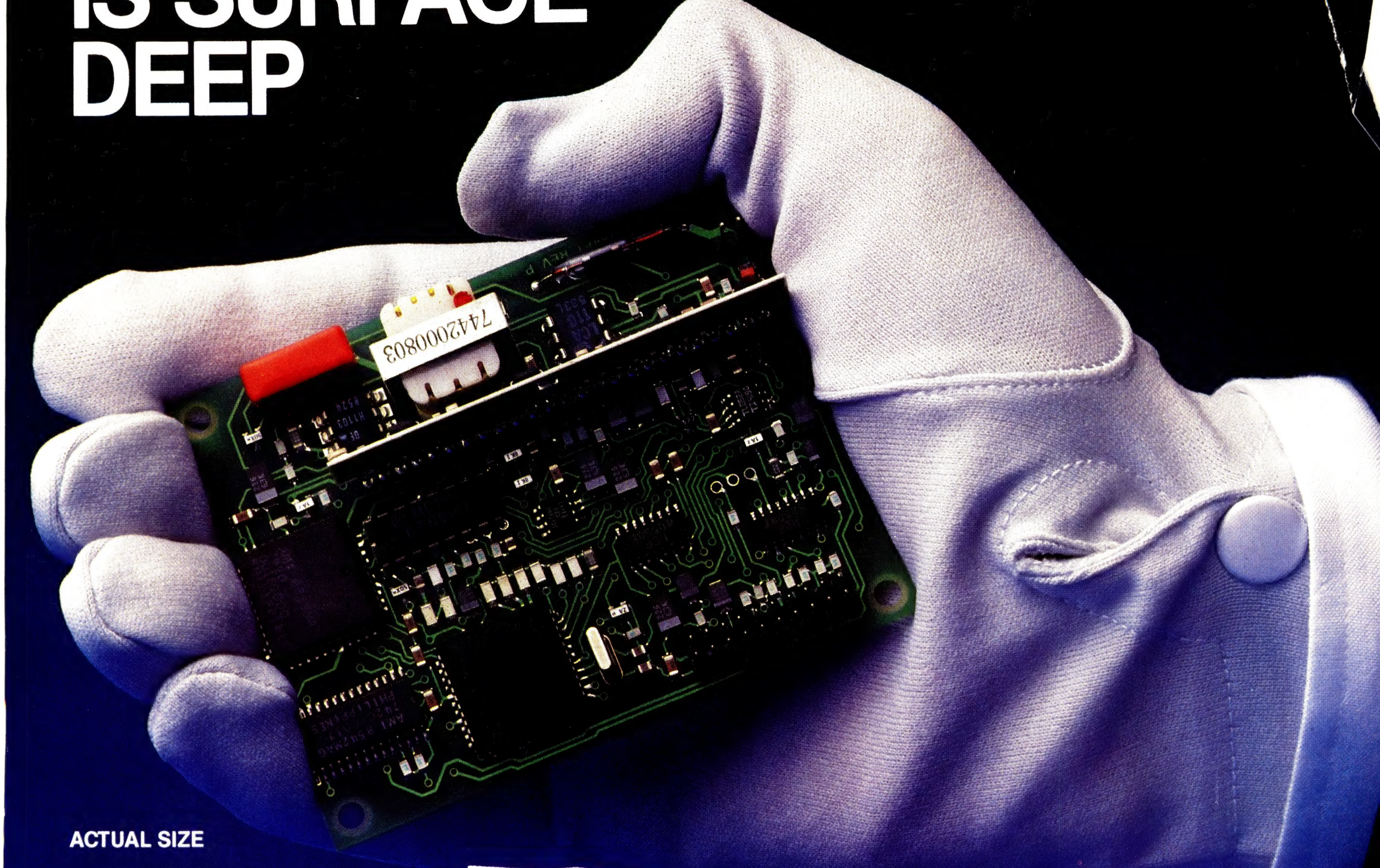
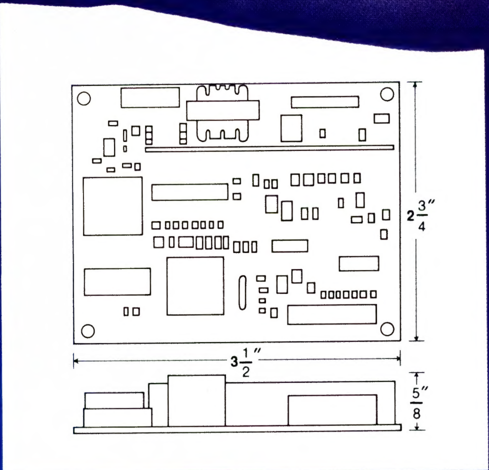


ACTUAL SIZE



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